

SPECIFICATION

INFORMATION RECORDING APPARATUS, AND GLASS SUBSTRATE FOR
INFORMATION RECORDING MEDIUM AND MAGNETIC RECORDING MEDIUM
USED IN THE INFORMATION RECORDING APPARATUS

TECHNICAL FIELD

[0001] The present invention relates to an information recording apparatus, and a glass substrate for an information recording medium and a magnetic recording medium used in the information recording apparatus.

BACKGROUND

[0002] In the past, as a substrate for an information recording medium in an information recording apparatus utilized in a computer and so forth, an aluminum substrate has been conventionally used, but a glass substrate exhibiting higher hardness, strength and surface evenness is increasingly employed in comparison to the aluminum substrate. In the case of a magnetic recording disk, high density recording together with downsizing and formation of a thinner plate is performed, and a magnetic head mechanism accompanied with low flying height of a magnetic head is moved from a CSS (Contact Start Stop) system to a LUL (Load

Unload) system. Since in the case of the LUL system, low flying height operation of the magnetic head is possible to be conducted in comparison to the CSS system, higher density recording becomes possible, whereby large capacity in recording can be taken care of. Thus, in accordance with the movement from the CSS system to the LUL system, glass substrates are increasingly employed.

[0003] The magnetic disk in which a magnetic layer is provided on a glass substrate is to be secured to a hub as the rotational axis of a spindle motor (SPM) installed in a magnetic disk recording apparatus. As the method of securing a magnetic disk to a hub, there are a method of holding with a plane at high accuracy and another plane at high accuracy with each other, and another method of holding with a plane at high accuracy and a toric protrusion. Specifically, the following cases are to be provided. (1) A method of holding with an end face of a spacer having the surface at high accuracy and another end face of a spacer having the surface at high accuracy with each other. (2) A method of holding with an end face of a spacer having the surface at high accuracy and a clamper having a toric protrusion. (3) A method of holding with a flange having the identical protrusion to that of the clamper and serving as a magnetic disk backup section

provided in the outer circumference at the lower end portion of the hub and an end face of the spacer having the surface at high accuracy.

[0004] The case of three magnetic disks secured to the hub is taken as an example. A magnetic disk, a spacer, a magnetic disk, a spacer and a magnetic disk provided in order on the flange are inserted in the hub, and the clamper is finally secured at the top of the hub. This clamper is worked via spring action, and the clamper is secured at the top of the hub by activating this spring action, whereby pressing force is generated by the flange and the clamper, and the magnetic disk is secured to the hub.

[0005] The conventional securing method of the magnetic disk was a securing method by which the flat area of the disk is sandwiched and held by both surfaces. When there is a protrusion or the like at the inner circumferential end portion of the magnetic disk secured to the hub, that is, at the inner circumferential end portion of a glass substrate as a substrate of the magnetic disk, produced is a problem such that the tilted magnetic disk is fixed in a state of distortion, and in the case of a substrate having weak mechanical strength, there appears generation of cracks. Accordingly, known is a glass substrate having a

shape falling within the range of $\pm 0.35 \mu\text{m}$ by reference to the flat plane of the main surface (refer to Patent Document 1, for example).

Patent Document 1: Japanese Patent O.P.I. Publication No. 2001-167427

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0006] However, when the inventors performed experiments, the glass substrate was often damaged even in the case of the shape at the inner circumferential end portion as described in Patent Document 1. In this case, there was no problem produced in the situation where a magnetic disk recording apparatus fitted with the glass substrate was conventionally used, but when strong impact such as dropping impact or the like was applied to the magnetic disk recording apparatus, the glass substrate was often damaged at the portion in which the glass substrate was secured to the hub.

[0007] The present invention has been made on the basis of the above-described situation, and it is an object of the present invention to provide an undamaged glass substrate for an information recording medium and a magnetic recording medium fitted with this substrate which

are stably secured to the hub of SPM (spindle motor), even though strong impact is applied to a magnetic disk recording apparatus equipped with the SPM.

MEANS TO SOLVE THE PROBLEMS

[0008] The above-described problems are solved by the following Structures.

[0009] (Structure 1) An information recording apparatus comprising:

 a toroidally-shaped glass substrate for an information recording medium comprising a main surface having a flat area and concentric outer and inner circumferential end faces,

 a spindle motor comprising a rotatable hub,

 a first holding member having a first shape in which the holding member is fit in an outer circumference of the hub and inserted into a hole formed from the inner circumferential end face; a surface facing the main surface is flat; and another outer circumference of the facing surface has a circular shape of radius R_s with a central axis as the hole, and

 a second holding member having a second shape comprising a toric protrusion at radius R_p smaller than the

radius R_s with the central axis as the hole, on the surface facing the main surface,

the information recording apparatus in which the glass substrate for the information recording medium is sandwiched and held by the first holding member and the second holding member to secure the glass substrate to the hub,

wherein position P1 where distance R_1 from the central axis of the glass substrate, on one contour of the main surface in a cross-section perpendicular to the main surface in a radial direction of the glass substrate, is set to R_0 of the hole radius + 5 mm and position P3 where distance R_3 from the central axis of the glass substrate is set to R_0 of the hole radius + 0.35 mm are specified on the same cross-section,

the contour is directed away from a reference plane based on the flat area of the main surface to a thickness direction of the glass surface at position P2 between the position P1 and the position P3, and

the following conditions are satisfied:

[0010] value of distance R_3 < value of radius R_s < value of distance R_2

value of distance R_3 < value of radius R_p < value of distance R_2

$$0.001 \mu\text{m} < \Delta h < 5.0 \mu\text{m},$$

provided that a distance from the central axis of the glass substrate to the position P2 is set to distance R2, and another distance between the reference plane and the position P3 is set to Δh .

[0011] (Structure 2) The information recording apparatus of Structure 1 comprising front and back surfaces of the glass substrate, being symmetrical to each other in shape.

[0012] (Structure 3) The information recording apparatus of Structure 1 comprising a magnetic layer provided on a surface of the glass substrate.

[0013] (Structure 4) A glass substrate for an information recording medium comprising a toroidal shape comprising a main surface having a flat area and concentric outer and inner circumferential end faces, where a rotatable hub of a spindle motor in an information recording apparatus is fit in an outer circumference of the hub, and inserted in a hole formed from the inner circumferential end face, the glass substrate sandwiched and held by:

a first holding member having a first shape in which a surface facing the main surface is flat, and an outer

circumference of the facing surface has a circular shape of radius R_s with a central axis as the hole, and

a second holding member having a second shape comprising a toric protrusion at radius R_p smaller than the radius R_s with the central axis as the hole, on the surface facing the main surface,

wherein position P1 where distance R_1 from the central axis of the glass substrate, on one contour of the main surface in a cross-section perpendicular to the main surface in a radial direction of the glass substrate, is set to R_0 of the hole radius + 5 mm and position P3 where distance R_3 from the central axis of the glass substrate is set to R_0 of the hole radius + 0.35 mm are specified on the same cross-section,

the contour is directed away from a reference plane based on the flat area of the main surface to a thickness direction of the glass surface at position P2 between the position P1 and the position P3, and

the following conditions are satisfied:

value of distance R_3 < value of radius R_s < value of distance R_2

value of distance R_3 < value of radius R_p < value of distance R_2

$0.001 \text{ mm} < \Delta h < 5.0 \text{ mm}$,

where a distance from the central axis of the glass substrate to the position P2 is set to distance R2, and another distance between the reference plane and the position P3 is set to Δh .

(Structure 5) A magnetic recording medium comprising a magnetic layer provided on a surface of the glass substrate of Structure 4.

EFFECT OF THE INVENTION

[0014] As to an information recording apparatus in which a glass substrate for an information recording medium is sandwiched and held by the first holding member having the first shape and the second holding member having the second shape which are specified, and is secured to a hub, there is the specified relationship between shape of the first and second holding members and shape of the inner circumferential end portion of the glass substrate

[0015] The glass substrate is secured to the hub of a spindle motor while having appropriate contact area and spacing with the first shape and the second holding member. For this reason, impact traveling from the hub to the glass substrate for an information recording medium is sufficiently absorbed and relaxed when traveling to the

glass substrate through the first and second holding members.

[0016] Accordingly, not only the glass substrate is stably secured to the hub of SPM, but also the glass substrate for an information recording medium is not damaged even though strong impact has been applied to an information recording apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Fig. 1 is a cross-sectional view cut in a plane perpendicular to the main surface, passing through the center of a glass substrate for an information recording medium, which shows an enlarged schematic drawing of an inner circumferential end portion

Fig. 2 is a schematic diagram of an entire structure of a glass substrate for an information recording medium.

Fig. 3 is a schematic diagram showing an example of a magnetic recording medium in which a magnetic layer is provided on the front main surface of a glass substrate for an information recording medium.

Fig. 4 is a schematic cross-sectional view of a magnetic disk recording apparatus fitted with three glass substrates for the information recording medium.

Fig. 5 is a flowchart showing an example of a manufacturing process of a glass substrate for the information recording medium.

Fig. 6 is a drawing to explain a jig for dropping experiments, which imitates a magnetic disk recording apparatus for dropping experiments.

EXPLANATION OF NUMERALS

[0018] 1, 1A, 1B, 1C Glass substrate for information recording medium (Glass substrate)

2 Magnetic layer

10a Front main surface

10b Back main surface

13 Hole

14 Outer circumferential end face

15 Inner circumferential end face

20 Screw

30 Hub

30a Flange

30b Motor bracket

40, 82 Base

50 Spindle motor

60A, 60B Spacer

70, 90 Clamp

70p, 30p Protrusion

80 Jig for dropping experiments

84 Cover

92 Ramp

D, 86, 88 Magnetic recording medium (Magnetic disk)

P1, P2, P3, Pt Position

R1, R2, R3, Δh Distance

Rs, Rp Radius

BL Contour

SH Reference plane

C Central axis

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] The present invention will be described based on embodiments as shown in figures, but the present invention is not limited to the embodiments.

[0020] The inventors studied details of a glass substrate damaged by applied impact in the situation where it is installed in a magnetic disk recording apparatus, and of a peripheral portion of the glass substrate in the magnetic disk recording apparatus. As the result, the reason why the glass substrate to which impact is applied is damaged is presumably as follows.

[0021] The main surface of the glass substrate secured to a hub as a rotational axis of a spindle motor (SPM) is a specular surface since the foregoing main surface is a surface on which a recording layer is provided, and the end face with which the glass surface of the spacer to fix by sandwiching a glass substrate is brought into contact has also been subjected to a cutting finish treatment. When the spacer having such the excellent flatness or flat surface is brought into contact with a glass substrate, and secured to the glass substrate, the surfaces facing to each other are brought into contact with each other in large area, whereby excellent contact thereof can be obtained. Accordingly, the system is firmly secured to the hub. When impact is applied to a magnetic disk recording apparatus equipped with SPM in this situation via dropping from the outside, the portion secured to the hub by sandwiching the glass substrate between spacers is vibrated together with the hub. On the other hand, the portion not secured to the hub by sandwiching the glass substrate between spacers presumably produces large deformation in the direction perpendicular to the main surface of the glass substrate, taking outer circumferential end portion of the spacer secured to the hub as a supporting point. When this deforming amount exceeds a certain limit, the glass

substrate is considered to be broken. Therefore, the glass substrate does not produce a problem such as breakage or the like even in high speed rotation of SPM, but it is to be broken in application of impact such as dropping or the like. From this aspect, the glass substrate is desired to be loosely secured to the hub so as to absorb and relax impact, in such a way that the glass substrate is secured to the hub to such an extent that no problem is produced even in high speed rotation of the glass substrate, and no deformation is also produced to such an extent that the breakage occurs during application of impact. The present invention is accomplished by focusing on the above-described point.

[0022] Fig. 2 shows an entire structure of glass substrate 1 for an information recording medium in the present invention(hereinafter, referred to as a glass substrate). As shown in Fig. 1, glass substrate 1 is in the form of a circular disk where hole 13 is formed in the center. Numerals 14, 15, 10a and 10b represent an outer circumferential end face, an inner circumferential end face, a front main surface and a back main surface, respectively.

[0023] Further, Fig. 3 shows an example of magnetic recording medium D in which magnetic layer 2 is provided on

front main surface 10a of glass substrate 1 shown in Fig.

2. Magnetic layer 2 can be provided on back main surface 10b. Thickness of magnetic layer 2 is sufficiently thinner than that of glass substrate 1, and is nearly constant. For this reason, as to shape of the inner circumferential end portion in the present invention, glass substrate 1 is to be identical to magnetic recording medium D. Thus, after this, magnetic recording medium D is explained as glass substrate 1 being a substrate thereof, unless otherwise specifically mentioned.

[0024] Fig. 4 shows a schematic cross-sectional view of a magnetic disk recording apparatus fitted with three glass substrates (magnetic recording media) 1A, 1B and 1C.

Numeral 40 represents a base of a magnetic disk recording apparatus. Numeral 50 represents a spindle motor (SPM) to rotate glass substrates 1A, 1B and 1C. Numerals 60A and 60B each represents a spacer. Numeral 70 represents a clamp. Numeral 20 represents a screw to secure clamp 70 to the top of hub 30. SPM 50 is composed of rotatable hub 30, flange 30a to serve as a magnetic disk backup section provided in the lower end portion outer circumference of the hub, and motor bracket 30b to secure SPM 50 to the base.

[0025] A hole to fit spacers 60A and 60B in hub 30 is provide in the center, and the spacers are in the form of a

ring. Both end faces of the ring shape are parallel, and are subjected to surface-cutting at high accuracy. Spacers 60A and 60B maintains the spacing of each of glass substrates 1a, 1B and 1C at a given distance. The radius of the outer circumferential end of each of spacers 60A and 60B is radius R_s . Accordingly, spacers 60A and 60B each correspond to the first holding member.

[0026] Clamp 70 is in the form of a circular disk made of a material exhibiting spring action. Toric protrusion 70p is provided in the outer circumferential end portion of one surface of clamp 70, and the tip portion of protrusion 70P is designed to be brought into contact with glass substrate 1A wherein this tip portion has a rounded shape. The tip of protrusion 70p is located at the position of radius R_p from the center of clamp 70. Radius R_p is smaller than radius R_s . Accordingly, clamp 70 corresponds to the second holding member.

[0027] Flange 30a possesses toric protrusion 30p provided in the outer circumferential portion of the surface by which glass substrate 1C is supported, and the tip portion of protrusion 30P is designed to be brought into contact with magnetic recording medium 1C wherein this tip portion has a rounded shape. The tip of protrusion 30p is located at the position of radius R_p from the center of

flange 30a. Accordingly, flange 30a corresponds to the second holding member.

[0028] Magnetic recording medium 1C, spacer 60B, magnetic recording medium 1B, spacer 60A and magnetic recording medium 1A to be provided on flange 30a are inserted into hub 30 in order, and clamp 70 is finally secured to the tip of hub 30 with screw 20. By doing this, pressing force is generated between clamp 70 and flange 30a via spring action with clamp 70. Glass substrate 1C, spacer 60B, glass substrate 1B, spacer 60A and glass substrate 1A can be secured to hub 30 with this force.

[0029] The shape of inner circumferential portion of the glass substrate secured to the hub employing the flange, the spacer and the clamp, which has been explained, will be described.

[0030] A cross-section cut in a plane perpendicular to front main surface 10a, passing through the center of glass substrate 1 shown in Fig. 2 is taken into account. This cross-section is schematically shown in Fig. 1 by enlarging the peripheral portion of the inner circumferential end portion of glass substrate 1. As to the shape shown in Fig. 1, since back main surface 10b is symmetrical to front main surface 10a though having a margin of processing error, the side of front main surface 10a will be explained, and

explanation of the side of back main surface 10a will be omitted.

[0031] The following symbols are shown in Fig. 1. C represents the central axis of glass substrate 1. BL represents the contour of glass substrate 1 on the side of front main surface 10a. SH represents the reference plane based on the flat area of main surface 10 a. Pt represents a position of inner circumferential end face 15 where distance from central axis C of glass substrate 1 is R_0 . P3 represents a position where distance R_3 from central axis C is $R_0 + 0.35$ mm. P1 represents a position where distance R_1 from central axis C is $R_0 + 5$ mm. P2 is located between position P1 and position P2, and the value of distance R_2 from central axis C exceeds distance R_3 and less than distance R_1 . Contour BL extends toward inner circumferential end face 15 of the glass substrate from position P2 between position P1 and position P3, and in the direction moving away from the main surface.

[0032] Taking a 2.5 inch glass substrate for an example, position P1, position P2 and position P3 are as follows. When the center of glass substrate 1 is 0, and position Pt is 10 mm ($= R_0$), position P1 becomes 15 mm, and position P3 becomes 10.35 mm.

[0033] Contour BL in the direction of the inner circumferential end portion from front main surface 10a passes through position P1; starts declining from position P2 to the substrate side; passes through Pt; and reaches inner end face 15 at position Pt.

[0034] When the glass substrate secured to the hub is installed in a magnetic disk apparatus, and impact is applied to this magnetic disk apparatus, it has been found out via experiments that the glass substrate satisfying the following Conditions (1) to (3) is not damaged.

[0035] The value of distance R3, the value of distance R2, and the value of radius Rs of the outer circumferential end of spacers 60A and 60B each, satisfying the following condition.

value of distance R3 < value of radius Rs < value of distance R2 (1)

Further, the value of distance R3, the value of distance R2, and the value of radius Rp by which each of the position of toric protrusion 70p of clamp 70 and the position of toric protrusion 30p of flange 30a is specified satisfy the following condition.

value of distance R3 < value of radius Rp < value of distance R2 (2)

In addition, the value of radius R_p is smaller than the value of radius R_s .

Distance Δh between position P3 and reference plane SH based on the flat area of front main surface 10a satisfies the following condition.

$$0.001 \mu\text{m} < \Delta h < 5.0 \mu\text{m} \quad (3)$$

Glass substrates 1A, 1B and 1C where the inner circumferential end portion is formed, so as to satisfy the Conditions (1) to (3), are secured to hub 30 employing those such as the clamp, the flange and the spacer. In this case, the securing condition of glass substrates 1A, 1B and 1C shown in Fig. 4 is as follows.

[0036] The case of glass substrate 1A is as described below. The position where glass substrate 1A is brought into contact with spacer 60A is located outside the position where toric protrusion 70p of clamp 70 is brought into contact with glass substrate 1A. Further, the position where spacer 60A and toric protrusion 70p of clamp 70 are brought into contact with glass substrate 1A is a position located on the outer circumferential side from position P3, where the main surface of glass substrate 1A declines from main surface reference SH. Therefore, glass substrate 1A is sandwiched and held by applying stress forced from toric protrusion 70p of clamp 70 and the outer circumferential

portion of spacer 60A. In this case, the spacing between spacer 60A and position P3 of glass substrate 1A becomes Δh satisfying Condition (3). Accordingly, glass substrate 1A is secured to hub 30 so as to give appropriate contact area and spacing with the end face of spacer 60A.

[0037] In the case of glass substrate 1C, the case can be taken as an upside-down case with respect to the case of glass substrate 1A, and is as follows. The position where glass substrate 1C is brought into contact with spacer 60B is located outside the position where toric protrusion 30p of flange 30a is brought into contact with the glass substrate. Further, the position where spacer 60B and toric protrusion 30p of flange 30p are brought into contact with glass substrate 1C is a position located on the outer circumferential side from position P3, where the main surface of glass substrate 1C declines from main surface reference SH. Therefore, glass substrate 1C is sandwiched and held by applying stress forced from toric protrusion 30p of flange 30a and the outer circumferential portion of spacer 60B. In this case, the spacing between spacer 60B and position P3 of the glass substrate becomes Δh satisfying Condition (3). Accordingly, glass substrate 1C is secured to hub 30 so as to give appropriate contact area and spacing with the end face of spacer 60B.

[0038] In cases where of distance Δh shown in Condition (3) is at least $5.0\ \mu\text{m}$, the effect of sufficiently absorbing and relaxing impact is difficult to be obtained when the impact is generated by reducing too much of contact area between glass substrate 1A and spacer 60A, as well as between glass substrate 1C and spacer 60B. Further, in the case of a distance Δh of $0.001\ \mu\text{m}$ or less, produced is no looseness (spacing) between glass substrate 1A and spacer 60A, as well as between glass substrate 1C and spacer 60B, whereby stress is concentrated onto the surface of glass substrate 1A brought into contact with the outer circumferential end portion of spacer 60A, as well as of glass substrate 1C brought into contact with the outer circumferential end portion of spacer 60B when impact is generated, resulting in no acquisition of sufficient impact resistance.

[0039] In the present embodiment, radius R_{pf} as the value specifying the position of the tip of protrusion 30p included in flange 30a is set to the same radius R_p as the value specifying the position of the tip of protrusion 70p included in clamp 70, but they are not necessarily identical to each other and the value of radius R_{pf} may be

smaller than the value of radius R_s , satisfying Condition (2).

[0040] The glass substrate satisfying Conditions (1) - (3), when both main surfaces are sandwiched and held by spacers 60A and 60B in the case of glass substrate 1B, is not damaged even though applying impact in the same condition as in the case of being sandwiched and held with clamp 70 and spacer 60A, for example. For this reason, similarly to the case where both main surfaces are sandwiched and held with spacers 60A and 60B, the surface of flange 30a brought into contact with glass substrate 1C in the same manner as in the case of the end face of spacer 60B with no toric protrusion 30p may be subjected to a cutting finish treatment at high accuracy. In this case, when the radius up to the outer circumferential end face of the flange is set to radius R_{sf} , radius R_{sf} is preferably identical to radius R_s of the spacer.

[0041] The glass substrate for an information recording medium in the present invention is not limited to the magnetic recording medium, and is usable for a magnetooptical disk, an optical disk and so forth.

[0042] (Manufacturing process of glass substrate for information recording medium)

The manufacturing process of a glass substrate for an information recording medium will be described. Fig. 5 shows a flowchart showing an example of a manufacturing process of the glass substrate for the information recording medium. First, a glass material is melted (Glass-melting process), molten glass is cast into a lower die, and press-molding is conducted with an upper die to obtain a glass substrate precursor in the form of a circular disk (Press-molding process). In addition, the glass substrate precursor in the form of a circular disk may be prepared by cutting sheet glass formed via a down-draw process or a float process employing a grinding wheel.

[0043] A hole is made in the center of the glass substrate precursor formed via press-molding, employing a core-drill or the like equipped with a diamond grindstone (Coring process). Next, both surfaces of the glass substrate is subjected to a grinding process treatment, for example, while supplying grinding liquid to a commonly known dual-surface grinding machine employing diamond pellets, and a whole shape of the glass substrate, that is, parallelism, flatness and thickness of the glass substrate are preliminarily adjusted (First lapping process).

[0044] Next, the outer and inner circumferential end faces of the glass substrate are cut and chamfered, and the

outer diameter dimension and circularity of the glass substrate, the inner diameter of the hole, and concentricity of the glass substrate and the hole are finely adjusted (Inner/outer diameter processing process). After this, the inner circumferential end face of the glass substrate is ground to remove fine scratches and so forth (Inner circumferential end face processing process).

[0045] Next, the both surfaces of the glass substrate is subjected to a grinding treatment employing diamond pellets finer than those used in the first lapping process, and parallelism, flatness and thickness of the glass substrate are finely adjusted (Second lapping process). Next, the outer circumferential end face of the glass substrate is ground to remove fine scratches and so forth (Outer circumferential end face processing process).

[0046] Next, after washing the glass substrate, the glass substrate is immersed in chemical strengthening liquid to form a chemical strengthening layer on the glass substrate in order to improve impact resistance, vibration resistance and so forth (Chemical strengthening process). The chemical strengthening method is not specifically limited as long as it is a commonly known chemical strengthening method, but low temperature type chemical strengthening and so forth, in which ion exchange is

conducted in the region not exceeding a transition temperature in view of the glass transition point, are preferable. Examples of the alkali molten salt employed for chemical strengthening include potassium nitrate, sodium nitrate, a nitrate salt obtained by mixing those, and so forth.

[0047] After this, the glass substrate surface is subjected to grinding processing for precise finishing while supplying grinding liquid as a grinding agent such as cerium oxide or the like into a commonly known dual-surface grinding machine in which urethane form, suede or the like is used for a pad (Polishing process). The polishing process may be divided into plural process such as the first polishing process and the second polishing process by changing the pad and the grinding agent, depending on manufacturing efficiency and desired surface roughness. Surface roughness R_{max} and R_a can be adjusted to fall within the range of 2 - 6 nm and 0.2 - 0.4 nm, respectively by adjusting the utilized pad, grinding liquid, and the setting condition of a grinding machine. In addition, flatness can be 5 μm or less. Then, after conducting a washing process and an inspection process, the glass substrate as a product can be produced.

[0048] Herein, Ra (center line average roughness) and Rmax (maximum height) are specified by JIS B0601. These can be measured with an atomic force microscope.

[0049] In addition, the method of manufacturing a glass substrate for an information recording medium may possess various processes other than the above-described. Examples thereof include an annealing process to relax internal stress of the glass substrate, a heat-shock process to confirm reliability in strength of the glass substrate, a washing process to remove foreign matter such as a grinding agent, a chemical strengthening treatment solution and so forth which are left over on the surface of the glass substrate, various inspection·evaluation processes, and so forth. Further, the chemically strengthened region on the surface of the glass substrate is reduced by conducting a polishing process. Whether or not the chemically strengthened region is left over on the surface of the glass substrate is not limited, and thickness of the remaining strengthened region is not also limited.

[0050] In such the way, a glass substrate for an information recording medium is manufactured. The glass substrate for the information recording medium having shape of the inner circumferential end portion of the present invention is obtained by appropriately adjusting the

conditions of the inner circumferential end face processing process to the polishing process.

[0051] (Glass substrate)

The glass substrate is not specifically limited as long as it is glass capable of chemical-strengthening via ion exchange. Usable examples thereof include soda lime glass composed of SiO_2 , Na_2O , and CaO as a principal component, aluminosilicate glass composed of SiO_2 , Al_2O_3 , R_2O ($\text{R} = \text{K}$, Na , and Li) as a principal component, borosilicate glass, Li_2O - SiO_2 system glass, Li_2O - Al_2O_3 - SiO_2 system glass, and $\text{R}'\text{O}$ - Al_2O_3 - SiO_2 system glass ($\text{R}' = \text{Mg}$, Ca , Sr , and Ba). Of these, aluminosilicate glass and borosilicate glass are preferable in view of excellent impact resistance and excellent vibration resistance.

[0052] (Magnetic recording medium)

An information recording medium can be obtained by forming at least a recording layer on the glass substrate for an information recording medium of the present invention. The recording layer is not specifically limited, and it is possible to use various recording layers utilizing properties of magnetism, light, magnetooptics and so forth, but the magnetic layer is specifically preferable for preparation of a magnetic recording layer (magnetic

disk) in which a magnetic layer is used specifically as a recording layer.

[0053] The magnetic material used for the magnetic layer is not limited, and is usable by appropriately selecting commonly known materials. Examples of those containing Co as a major component include CoPt, CoCr, CoNi, CoNiCr, CoCrTa, CoPtCr, CoNiPt, CoNiCrPt, CoNiCrTa, CoCrPtTa, CoCrPtSiO and so forth. Further, it is also possible to use a multilayer structure in which the magnetic layer is divided with a nonmagnetic film (Cr, CrMo, CrV and others) to reduce noise.

[0054] In addition to the above-described Co system materials, ferrite system material and iron-rare earth system materials, granular having a structure in which magnetic particles of Fe, Co, CoFe, CoNiPt or the like is dispersed in a nonmagnetic film made of SiO₂, BN or the like, and so forth can be utilized as the magnetic layer. The magnetic layer may be any of a longitudinal magnetic recording type magnetic layer and a perpendicular magnetic recording type magnetic layer.

[0055] As a method of forming a magnetic film, a commonly known method is usable. Examples thereof include a

sputtering method, an electroless plating method, a spin coating method and so forth.

[0056] A subbing layer, a protective layer, a lubricating layer and so forth may be provided in the magnetic recording medium, if desired. Each of these layers is usable by appropriately selecting commonly known materials. Examples of the material for the subbing layer include Cr, Mo, Ta, Ti, W, V, B, Al, Ni and so forth. Examples of the material for the protective layer include Cr, Cr alloy, C, ZrO_2 , SiO_2 and so forth. Further, examples of the lubricating layer include those in which a liquid lubricating agent made of perfluoropolyether (PFPE) or the like is coated, and having been subjected to a heat treatment, if desired, and so forth.

EXAMPLE

[0057] An aluminosilicate glass substrate having an outer diameter of 65 mm, an inner diameter of 20 mm and a plate thickness of 0.635 mm as a glass substrate for an information recording medium was prepared along manufacturing processes shown in Fig. 5.

[0058] Glass material composed of SiO_2 , Al_2O_3 , R_2O ($\text{R} = \text{K}, \text{Na}, \text{and Li}$) as a principal component is melted (Glass-melting process), molten glass is cast into a lower die,

and press-molding is conducted with an upper die to obtain a glass substrate precursor in the form of a circular disk (Press-molding process).

[0059] A hole was made in the center of the glass substrate precursor formed via press-molding, employing a core-drill equipped with a diamond grindstone (Coring process). Next, both surfaces of the glass substrate is subjected to a grinding process treatment while supplying grinding liquid to a commonly known dual-surface lapping machine employing diamond pellets of #1000 mesh, and parallelism, flatness and thickness of the glass substrate were preliminarily adjusted (First lapping process).

[0060] Next, the outer and inner circumferential end faces of the glass substrate are cut, and a length of about 0.1 mm thereof is chamfered with a diamond grindstone in the form of a drum. The outer diameter dimension and circularity of the glass substrate, the inner diameter of the hole, and concentricity of the glass substrate and the hole are finely adjusted (Inner/outer diameter processing process). Next, the inner circumferential end face of the glass substrate is subjected to brush-grinding while supplying grinding liquid to remove fine scratches and so forth (Inner circumferential end face processing process).

[0061] Next, the both surfaces of the glass substrate is again subjected to a grinding treatment by a dual surface lapping machine with diamond pellets of #1500 mesh while supplying grinding liquid to finely adjust parallelism, flatness and thickness of the glass substrate (Second lapping process), and the outer circumferential end face of the glass substrate is subjected to brush-grinding to remove fine scratches and so forth (Outer circumferential end face processing process).

[0062] Next, after washing the glass substrate, the glass substrate is immersed in chemical strengthening liquid to form a chemical strengthening layer on the glass substrate. A chemical strengthening agent in which NaNO_3 and KNO_3 are mixed in a ratio of 5 : 5 is charged in a chemical strengthening vessel, and the system is heated to 375 °C to prepare chemical strengthening liquid.

[0063] After this, the glass substrate surface is subjected to grinding processing for precise finishing (Polishing process). In the polishing process, both surfaces of the glass substrate were subjected to a grinding process treatment by a commonly known dual surface grinding machine equipped with a pad while supplying grinding liquid. Glass substrates No. 1 to No. 17 having various shapes of the inner circumferential end face as

samples were obtained by changing conditions such as kinds and particle diameter of polishing material used for the grinding liquid supplied to a grinding machine, the number of rotation of a surface plate fitted with a pad brought into contact with both surfaces of the glass substrate, pad pressure against the glass substrate and so forth. Surface roughness of these glass substrates falls within the R_{max} range of 2 - 6 nm, and falls within the R_a range of 0.2 - 0.4 nm.

[0064] After washing the glass substrate, a magnetic film was prepared on this glass substrate to form a magnetic recording medium. As for the magnetic film, a subbing layer (a thickness of about 100 nm) formed of Ni-Al, a recording layer (a thickness of 20 nm) formed of Co-Cr-Pt and a protective film (a thickness of 5 nm) were layered from the glass substrate side in order. In this case, the magnetic film has a thickness much thinner than that of the glass substrate.

[0065] As for the produced magnetic recording medium shown in Fig. 4, a glass substrate, a spacer and a glass substrate in this order are inserted into a hub of SPM having a flange to secure two glass substrates employing a clamp. This SPM was installed in jig 80 for dropping experiments as an imitated magnetic disk recording

apparatus shown in Fig. 6. In jig 80 for dropping experiments, numeral 80 represents a base formed from an aluminum die-cast to place SPM, numeral 84 represents a cover made of SUS, numerals 86 and 88 each represent a glass substrate, and numeral 90 represents a clamp. Further, similarly to a practical magnetic disk recording apparatus, ramp 92 to hold a magnetic head is provided. Five pieces of jig 80 for dropping experiments for each sample described below are arranged to be provided.

[0066] After this, when SPM of each jig 80 for dropping experiments was operated at 7200 rpm, any of Sample Nos. 1 - 17 was operated with no problem. Next, dropping experiments were carried out to check whether cracks of the glass plate were present or absent. The above-described jig 80 for dropping experiments is horizontally secured to a securing jig provided separately (situation where the glass substrate is horizontal) by the same securing method as in the actual magnetic disk recording apparatus. Jig 80 for dropping experiments together with this securing jig is dropped in the maintained horizontal situation. As to the impact of dropping, a back-up portion of the securing jig to be dropped at the lower place, and dropping height were adjusted in such a way that acceleration of initial impact of dropping, which is measured by an acceleration sensor

installed in the securing jig, was 1000 G, and time span in which this acceleration was maintained became 1 ms. As to the number of dropping of jig 80 for dropping experiments, three times of dropping were conducted in the situation where jig 80 for dropping experiments was installed in the securing jig so as to have a hub placed on the lower side, and three times of dropping were also conducted in the situation where jig 80 for dropping experiments was installed in the securing jig so as to place the above-described system upside down.

[0067] The results are shown in Table 1.

Specifications of the flange, spacer and clamp to secure the magnetic recording medium used this time to the hub of SMP are shown in Table 2. In addition, since a hole of the glass substrate has a radius of 10 mm, the value of distance R1 is 15 mm, and the value of distance R3 is 10.35 mm.

[0068] [Table 1]

Sample No.	Distance R2 (mm)	Δh (μm)	Damage caused by dropping
1	12.8	0.003	Not damaged
2	12.8	0.1	Not damaged
3	13.1	0.5	Not damaged
4	12.9	1.1	Not damaged
5	12.9	3.3	Not damaged
6	12.8	4.1	Not damaged
7	12.7	4.8	Not damaged
8	13.2	4.9	Not damaged
9	12.2	3.1	Not damaged
10	12.8	-0.003	Damaged
11	12.9	0.001	Damaged
12	13.0	5	Damaged
13	12.9	5.2	Damaged
14	12.8	5.6	Damaged
15	11.8	1.4	Damaged
16	11.6	2.7	Damaged
17	11.3	1.9	Damaged

[0069] [Table 2]

Name of member	Material	Radius Rp	Radius Rs	Thickness
Flange	Aluminum alloy	11.45 mm	-	-
Spacer	Alumina	-	11.9 mm	2.35 mm
Clamp	SUS410	11.45 mm	-	0.5 mm

[0070] As is clear from the results shown above, it can be confirmed that the magnetic recording medium having the shape satisfying Conditions (1) to (3) is stably secured to a hub of SPM (spindle motor), and is not damaged even when strong impact is applied to a magnetic disk recording apparatus in which SPM is installed.

CLAIMS

1. An information recording apparatus comprising:
 - a toroidally-shaped glass substrate for an information recording medium comprising a main surface having a flat area and concentric outer and inner circumferential end faces,
 - a spindle motor comprising a rotatable hub,
 - a first holding member having a first shape in which the holding member is fit in an outer circumference of the hub and inserted into a hole formed from the inner circumferential end face; a surface facing the main surface is flat; and another outer circumference of the facing surface has a circular shape of radius R_s with a central axis as the hole, and
 - a second holding member having a second shape comprising a toric protrusion at radius R_p smaller than the radius R_s with the central axis as the hole, on the surface facing the main surface,
- the information recording apparatus in which the glass substrate for the information recording medium is sandwiched and held by the first holding member and the second holding member to secure the glass substrate to the hub,

wherein position P1 where distance R1 from the central axis of the glass substrate, on one contour of the main surface in a cross-section perpendicular to the main surface in a radial direction of the glass substrate, is set to R0 of the hole radius + 5 mm and position P3 where distance R3 from the central axis of the glass substrate is set to R0 of the hole radius + 0.35 mm are specified on the same cross-section,

the contour is directed away from a reference plane based on the flat area of the main surface to a thickness direction of the glass surface at position P2 between the position P1 and the position P3, and

the following conditions are satisfied:

value of distance R3 < value of radius Rs < value of distance R2

value of distance R3 < value of radius Rp < value of distance R2

$$0.001 \text{ } \mu\text{m} < \Delta h < 5.0 \text{ } \mu\text{m},$$

where a distance from the central axis of the glass substrate to the position P2 is set to distance R2, and another distance between the reference plane and the position P3 is set to Δh .

2. The information recording apparatus of Claim 1 comprising front and back surfaces of the glass substrate, being symmetrical to each other in shape.

3. The information recording apparatus of Claim 1 comprising a magnetic layer provided on a surface of the glass substrate.

4. A glass substrate for an information recording medium comprising a toroidal shape comprising a main surface having a flat area and concentric outer and inner circumferential end faces, where a rotatable hub of a spindle motor in an information recording apparatus is fit in an outer circumference of the hub, and inserted in a hole formed from the inner circumferential end face, the glass substrate sandwiched and held by:

a first holding member having a first shape in which a surface facing the main surface is flat, and an outer circumference of the facing surface has a circular shape of radius R_s with a central axis as the hole, and

a second holding member having a second shape comprising a toric protrusion at radius R_p smaller than the radius R_s with the central axis as the hole, on the surface facing the main surface,

wherein position P1 where distance R1 from the central axis of the glass substrate, on one contour of the main surface in a cross-section perpendicular to the main surface in a radial direction of the glass substrate, is set to R0 of the hole radius + 5 mm and position P3 where distance R3 from the central axis of the glass substrate is set to R0 of the hole radius + 0.35 mm are specified on the same cross-section,

the contour is directed away from a reference plane based on the flat area of the main surface to a thickness direction of the glass surface at position P2 between the position P1 and the position P3, and

the following conditions are satisfied:

value of distance R3 < value of radius Rs < value of distance R2

value of distance R3 < value of radius Rp < value of distance R2

$0.001 \text{ mm} < \Delta h < 5.0 \text{ mm}$,

where a distance from the central axis of the glass substrate to the position P2 is set to distance R2, and another distance between the reference plane and the position P3 is set to Δh .

5. A magnetic recording medium comprising a magnetic layer provided on a surface of the glass substrate of Claim 4.