

[Designation of Document] Specification

[Title of the Invention]

GLASS SUBSTRATE FOR MAGNETIC RECORDING MEDIUM, AND
MAGNETIC RECORDING MEDIUM USING GLASS SUBSTRATE FOR
5 MAGNETIC RECORDING MEDIUM

[Technical Field]

[0001]

The present invention relates to a glass substrate for a magnetic recording medium and a magnetic recording medium.

10 [Background Art]

[0002]

In recent years, in magnetic disk devices, a rapid increase in recording density has been advancing. In the magnetic disk devices, both of an increase in recording density and high-speed access have been achieved by flying a magnetic head
15 slightly over a magnetic recording medium (magnetic disk) which is rotating at a high speed, and by scanning it over the surface. Although a substrate where nickel-phosphorus (Ni-P) is plated on aluminum (Al) has been conventionally the mainstream of the base material for the magnetic disks, a glass substrate has begun to use, which is hard as compared with the aluminum alloy substrate, is excellent in resistance against
20 shock by the magnetic head, and also is excellent in flatness and smoothness.

[0003]

In the magnetic disk devices, in order to enhance the recording density, there is a tendency to further reduce flying height of the magnetic head. With the reduction thereof, there is an increasing risk that troubles such as a head crash that the
25 magnetic head collides with the magnetic recording medium (magnetic disk) occur. On the other hand, in order to realize the high-speed access to data on the magnetic disk,

it becomes necessary to rotate the magnetic disk at a high speed. However, since vibration of the magnetic disk called fluttering occurs by an air stream generated by the high-speed rotation of the magnetic disk, flying stability of the magnetic head decreases and there arises a problem that the troubles such as the head crash are further prone to occur. Moreover, there is also a concern that the magnetic head comes into contact with a surface of the magnetic disk to damage the magnetic disk. Therefore, it becomes more important as before to suppress the fluttering of the magnetic disk at the high-speed rotation.

[0004]

Hitherto, there has been proposed a magnetic disk device in which impact strength of the glass substrate is improved by defining a cross-sectional shape of the inner peripheral part of the glass substrate to be fixed to a hub of a spindle motor (e.g., see Patent Document 1). Moreover, there has been also proposed a magnetic disk device in which deformation of the magnetic disk device is prevented and the flying of the magnetic head is stabilized by regulating the stiffness and structure of a member for attaching the magnetic disk to a hard disk drive (HDD) in a predetermined relationship (e.g., see Patent Document 2).

[0005]

However, since the deformation of shape of the magnetic disk attached to HDD and fluttering displacement generated from the deformation cannot be sufficiently suppressed in both of the magnetic disks described in Patent Documents 1 and 2, the flying stability of the magnetic head is decreased and thus the head crush and the like cannot be sufficiently prevented. Moreover, in the conventional magnetic disks, shock resistance is also not sufficient in the case where a shock is imparted to the magnetic disk devices by their falling or the like.

[Background-Art Documents]

[Patent Documents]

[0006]

Patent Document 1: WO 2008/111427

5 Patent Document 2: JP-A-2003-217249

[Summary of the Invention]

[Problems that the Invention is to Solve]

[0007]

The present invention is devised for solving the above problems and an
10 object thereof is to provide a glass substrate for a magnetic recording medium, which
suppresses the fluttering displacement at the time when the magnetic recording medium
is rotated at a high speed in the magnetic disk device and also improves the shock
resistance of the magnetic recording medium.

[Means for Solving the Problems]

15 [0008]

A glass substrate for a magnetic recording medium of the invention has a
disk shape, has a circular through hole at a center thereof and has one pair of main
surfaces facing to each other, wherein, in the main surfaces, a clamp area including a
position to be fastened with a fastening member at the time when the magnetic
20 recording medium is fixed to a hard disk drive has a flatness of 1 μm or less and a
thickness deviation of 0.3 μm or less.

[0009]

In the glass substrate for a magnetic recording medium of the invention, the
flatness said above is preferably 0.7 μm or less, more preferably 0.5 μm or less.
25 Additionally, in the main surfaces, the clamp area preferably has a surface waviness
amplitude value of 20 nm or less. The surface waviness amplitude value is preferably

10 nm or less. The thickness deviation said above is preferably 0.2 μm or less. Furthermore, the clamp area is preferably, in the main surfaces, a ring area present at a central side from a circumference of a circle which has a diameter being 128% of a diameter of the circular through hole and which is concentric with the circular through hole.

[0010]

A magnetic recording medium of the invention uses the glass substrate for a magnetic recording medium of the invention.

[Advantages of the Invention]

[0011]

According to the glass substrate for a magnetic recording medium of the invention, in the case where the magnetic recording medium in which a magnetic layer or the like is formed on a surface of the glass substrate for a magnetic recording medium is mounted on a magnetic disk device, since fluttering at the time when the magnetic recording medium is rotated at a high speed can be suppressed, generation of troubles such as a head crash can be prevented to improve reliability of the magnetic disk device and also an increase in recording density can be achieved. Moreover, even in the case where a strong shock is imparted onto the magnetic disk device, the magnetic recording medium is not damaged, so that a highly reliable magnetic disk device can be obtained.

[Brief description of the drawings]

[0012]

Fig. 1 is a cross-sectional perspective view showing one example of the glass substrate for a magnetic recording medium of the invention.

Fig. 2 is a plan view for explaining a method for measuring parallelism of polishing surfaces of upper and lower platens of a polishing machine in Examples of the invention.

Figs. 3 show shapes of polishing surfaces of upper and lower platens of a polishing machine and Fig. 3A is a cross-sectional view schematically showing the shapes where D2 is larger than D1 and Fig. 3B is a cross-sectional view schematically showing the shapes where D2 is smaller than D1.

5 [Modes for Carrying Out the Invention]

[0013]

The mode for carrying out the invention will be described below, but it should be understood that the invention is not construed as being limited to the following embodiments.

10 [0014]

The present inventors have found that flatness and the like of the predetermined areas of the glass substrate to be used in a magnetic disk (magnetic recording medium) exert an influence on a degree of displacement of the fluttering and on shock resistance of the magnetic disk in the case where a shock of falling or the like
15 is imparted to the magnetic disk device.

Namely, at the mounting of the magnetic disk on a hard disk drive (HDD), a predetermined position of the main surface of the magnetic disk near to an inner peripheral part thereof is fastened and fixed with a member such as a clamp (hereinafter referred to as clamp member) and also the clamp member is bound to a hub to attach the
20 disk to a spindle motor. In the case where the flatness of the position to be fastened and fixed with the clamp member in the main surface of the glass substrate for a magnetic recording medium is bad, the shape of the glass substrate is deformed when the clamp member is fastened, and the flatness as a whole magnetic disk becomes worse. As a result, the flying stability of the magnetic head decreases and the head
25 crash and the like are prone to occur. Here, an area including the position to be fastened and fixed with the clamp member is also referred to as clamp area.

[0015]

Moreover, in the case where the flatness of the clamp area of the glass substrate for a magnetic recording medium is bad, stress is concentrated on a convex part of the glass substrate to result in troubles that the impact strength is lowered, tolerance (margin) of the shock resistance is decreased, and the like when the area is fastened and fixed with the clamp member.

[0016]

Furthermore, in the case where the thickness of the portion corresponding to the clamp area is not even in the glass substrate for a magnetic recording medium, when the area is fastened and fixed with the clamp member, the glass substrate is not properly fixed and there arises a problem that fluttering increases when the magnetic disk is rotated at a high speed. As a result, the flying stability of the magnetic head decreases and the head crash and the like are prone to occur.

[0017]

The glass substrate for a magnetic recording medium of the embodiment of the invention is a disk-shaped glass substrate for a magnetic recording medium having a circular through hole at a center thereof and having one pair of main surfaces facing to each other. Also, the glass substrate is characterized in that, in one pair of the main surfaces, the flatness of the clamp area is 1 μm or less and the thickness deviation of the glass substrate in the clamp area is 0.3 μm or less.

[0018]

First, one example of the glass substrate for a magnetic recording medium of the invention is shown in Fig. 1. The glass substrate 10 for a magnetic recording medium of the invention has a circular hole 11, which is a circular through hole, at the center thereof and has a disk shape including an inner peripheral side surface 101 that is an inner wall surface of the circular hole 11, an outer peripheral side surface 102 and

one pair of upper and lower main surfaces 103. Moreover, at an intersecting parts of the inner peripheral side surface 101 and the outer peripheral side surface 102 with the upper and lower both main surfaces 103, chamfered parts 104 (an inner peripheral chamfered part and an outer peripheral chamfered part) are formed. Also, in the upper and lower both main surfaces 103 that are one pair of the main surfaces, the flatness of the clamp area 105 is 1 μm or less and the thickness deviation of the glass substrate 10 at the clamp area 105 is 0.3 μm or less.

[0019]

In the present Description, the clamp area 105 means an area including a position of the main surface to be fastened and fixed with a fastening member such as a clamp at the time when the glass substrate 10 for a magnetic recording medium is used as a magnetic recording medium with installing the substrate in HDD.

Specifically, in the predetermined main surface 103, a ring (ring at a central side from the circumference of 105a) area from the circumference of a circle (hereinafter referred to as concentric circle) 105a which has a diameter ($1.28D_1$) that is 128% of the inner diameter D_1 of the circular hole 11 and which is concentric with the circular hole to the inner peripheral part 105b of the main surface 103 is preferably defined as the clamp area 105, including a position of the main surface to be fastened and fixed with a fastening member such as a clamp. For example, in the case of the glass substrate 10 for a magnetic recording medium having an outer diameter of 65 mm and an inner diameter D_1 of the circular hole 11 of 20 mm, fastening and fixing with a fastening member is performed at an area (clamp area 105) from the circumference of the concentric circle having a diameter of 25.6 mm to the inner peripheral part 105b or a part thereof, in the main surface 103. Moreover, in the case of the glass substrate 10 for a magnetic recording medium having an outer diameter of 95 mm and an inner diameter D_1 of the circular hole 11 of 25 mm, an area from the circumference of the

concentric circle 105a having a diameter of 32.0 mm to the inner peripheral part 105b becomes the clamp area 105, in the main surface 103, and the fastening and fixing with a fastening member such as a clamp is to be performed at an inside area from the area.

[0020]

5 The flatness of such a clamp area 105 is represented by a TIR (Total Indicated Runout) value that is a difference between the maximum peak height and the maximum valley depth. The flatness can be measured by a phase-shift interferometry (phase shift method) at a determined measuring wavelength using an interferometric flatness meter.

10 [0021]

 In the glass substrate for a magnetic recording medium of the invention, the flatness of the clamp area 105 of the main surface is 1 μm or less, preferably 0.7 μm or less, further preferably 0.5 μm or less, and particularly preferably 0.3 μm or less. When the flatness exceeds 1.0 μm , vibration (fluttering displacement) of the magnetic
15 recording medium at high-speed rotation increases and there is a concern that troubles such as the head crash occurs.

[0022]

 Moreover, in the glass substrate for a magnetic recording medium of the invention, the thickness deviation of the glass substrate 10 for a magnetic recording
20 medium in the clamp area 105 is 0.3 μm or less, preferably 0.2 μm or less, and further preferably 0.1 μm or less. In the case where the thickness deviation exceeds 0.3 μm , even when the flatness of clamp area 105 of the main surface 103 is 1 μm or less, the fluttering displacement at the time when the magnetic recording medium is rotated at a high speed increases and there is a concern that troubles such as the head crash occur.

25 [0023]

The thickness deviation of the glass substrate 10 in the clamp area 105 is determined by the method shown below. Namely, thickness is measured at a plurality of positions within the clamp area 105 of the glass substrate 10 for a magnetic recording medium (for example, 4 positions having a central angle of 0°, 90°, 180°, and 270° on the circumference of the concentric circle 105a) using a thickness measuring apparatus for a glass substrate and a difference between the maximum value and the minimum value of the resulting thickness values is determined and is taken as thickness deviation.

[0024]

Furthermore, in the glass substrate 10 for a magnetic recording medium of the invention, in the upper and lower both main surfaces 103, the surface waviness amplitude value of the clamp area 105 is preferably 20 nm or less.

[0025]

Here, the surface waviness means a minute waviness shape having a cycle of several tens μm to several mm in the main surface of the glass substrate 10 for a magnetic recording medium. Moreover, the surface waviness amplitude value means a PV (Peak to Valley) value that is a difference between the maximum peak height and the minimum valley depth of the waviness shape.

In the invention, the amplitude value (PV value) of the surface waviness having a period of 500 μm to 5000 μm is preferably 20 nm or less. The surface waviness amplitude value (PV value) is more preferably 10 nm or less and further preferably 5 nm or less.

[0026]

By reducing the surface waviness amplitude value (PV value) of clamp area of the glass substrate for a magnetic recording medium, it is possible to suppress the concentration of stress on the convex part of the glass substrate and the decrease in impact strength and increase the tolerance (margin) of the shock resistance. Therefore,

in the case where the surface waviness amplitude value (PV value) is 20 nm or less, a magnetic recording medium having a high shock resistance can be obtained. Namely, even in the case where a strong shock is imparted to the magnetic disk device, the mounted magnetic recording medium is not easily damaged.

5 [0027]

The surface waviness of the glass substrate 10 for a magnetic recording medium is measured, for example, with setting a band path filter in the range of 500 μm to 5000 μm by an interferometry with a white light using a white light interferometric shape measuring instrument. Then, the PV value that is the difference between the maximum peak height and the minimum valley depth of the measured surface waviness is determined and taken as a surface waviness amplitude value.

[0028]

In the thus constructed glass substrate 10 for a magnetic recording medium of the embodiment, since the flatness of clamp area 105 of the main surface 103 is 1 μm or less and also the thickness deviation of the glass substrate 10 in the clamp area 105 is 0.3 μm or less, the fluttering of the magnetic recording medium is suppressed in the magnetic disk device in which a magnetic recording medium obtained from the glass substrate 10 for a magnetic recording medium is fastened and fixed to HDD with the clamp member or the like. As a result, the flying stability of the magnetic head is improved and the troubles such as the head crash do not easily occur. Moreover, since local stress concentration in the clamp area is prevented, the shock resistance of the glass substrate for a magnetic recording medium is improved and, even when a strong shock is imparted to the magnetic disk device, the magnetic recording medium is not easily damaged.

25 [0029]

The glass substrate for a magnetic recording medium of the invention can be obtained by a manufacturing method having the following steps. In this regard, between the steps shown below, cleaning of the glass substrate (in-process cleaning) and etching of the glass substrate surface (a part or whole surface of the glass substrate) (in-process etching) may be performed. Moreover, in the case where the glass substrate for a magnetic recording medium is required to have high mechanical strength, a strengthening step (for example, a chemical strengthening step) of forming a strengthening layer (compressive stress layer) on a surface layer of the glass substrate may be conducted before or after the main surface polishing step or between the main surface polishing steps (between a primary polishing step and a secondary polishing step or between a secondary polishing step and a tertiary polishing step).

[0030]

<Circular Processing Step>

First, a glass sheet formed by a float process, a fusion process, a down draw process, or a press molding process is processed into a disk shape having a circular hole at the center thereof. The glass sheet may be any one formed by the float process, the fusion process, the down draw process, or the press molding process. Moreover, glass constituting the glass sheet may be amorphous glass or crystallized glass.

[0031]

<Chamfering Step>

The intersecting parts of the inner peripheral side surface with the upper and lower both main surfaces of the circularly processed glass substrate and the intersecting parts of the outer peripheral side surface with the upper and lower both main surfaces thereof are chamfered to form inner peripheral chamfered parts and outer peripheral chamfered parts.

[0032]

<Primary Lapping Step of Main Surface: Loose Abrasive Lapping Step>

In order to control the flatness and thickness of the glass substrate, the upper and lower both main surfaces of the glass substrate are lapped with a double side lapping machine or a one side lapping machine using a lapping slurry containing an abrasive (loose abrasive lapping step). As the loose abrasive, diamond particles, alumina particles, silicon carbide particles, and the like having an average particle size larger than that of the fixed abrasive to be used in the secondary lapping step mentioned below can be used. After the primary lapping, it is preferred to remove the abrasive by cleaning the glass substrate.

10 [0033]

<Secondary Lapping Step of Main Surface: Fixed Abrasive Lapping Step>

In order to control the flatness and thickness of the glass substrate, it is preferred to perform fixed abrasive lapping with a double side lapping machine or a one side lapping machine using a fixed abrasive tool. As the abrasive to be contained in the fixed abrasive tool, for example, diamond particles, alumina particles, silicon carbide particles, and the like having an average particle size of 0.5 to 10 μm can be used.

In this regard, in the manufacturing step of the glass substrate for a magnetic recording medium, as the lapping step for controlling the flatness and thickness of the glass substrate, only the loose abrasive lapping step may be performed, only the fixed abrasive lapping step may be performed, or both of the loose abrasive lapping step and the fixed abrasive lapping step may be performed.

[0034]

<Peripheral Surface Polishing Step>

25 The inner peripheral surface (inner peripheral side surface and inner peripheral chamfered part) is polished using a polishing brush and a polishing slurry

containing an abrasive to remove scratches generated on the inner peripheral surface at circular processing and chamfering, thereby smoothening the surface to be a mirror surface. Moreover, the outer peripheral surface (outer peripheral side surface and outer peripheral chamfered part) is polished using a polishing brush and a polishing
5 slurry containing an abrasive to remove scratches generated on the outer peripheral surface at circular processing and chamfering, thereby smoothening the surface to be a mirror surface.

[0035]

In the peripheral surface polishing step, for example, it is preferred that
10 plural sheets of the glass substrates are stacked to form a glass substrate stack and polishing is conducted on the glass substrate stack using the polishing slurry and the polishing brush. The polishing of the inner peripheral surface and the polishing of the outer peripheral surface can be conducted simultaneously or can be conducted separately. Moreover, of the polishing of the inner peripheral surface and the
15 polishing of the outer peripheral surface, only one polishing may be conducted. In the case where the polishing of the inner peripheral surface and the polishing of the outer peripheral surface are conducted separately, the order thereof is not particularly limited and either of them may be conducted first. For example, it is possible to adopt a method wherein the polishing of the outer peripheral surface is conducted on the glass
20 substrate stack where the glass substrates are stacked, then the polishing of the inner surface is conducted still in the form of the glass substrate stack, thereafter the stack is separated into each sheet, each sheet of the glass substrate is accommodated in a cassette or the like, and the resulting one is transferred to the next step.

[0036]

25 As the abrasive, cerium oxide particles, silica particles, alumina particles, zirconia particles, zircon particles, silicon carbide particles, boron carbide particles,

diamond particles, manganese oxide particles, and the like can be used. From the viewpoint of a polishing rate, it is preferred to use cerium oxide particles. The average particle size of the abrasive is preferably 0.1 to 5 μm from the viewpoints of the efficiency of the peripheral surface polishing (polishing rate), smoothness of the peripheral surface obtained by polishing, and the like. In the Description, the average particle size is a d50 value which shows a particle size at 50% accumulation on particle size distribution. The average particle size is a value determined by measurement using a particle size analyzer of a laser diffraction type, a laser scattering type, or the like.

[0037]

<Main Surface Polishing Step>

The polishing of main surface of the glass substrate is conducted for removing scratches and the like generated at the circular processing and the chamfering, and the lapping or the like of the main surface and for smoothening unevenness to form a mirror surface. In the main surface polishing step, it is preferred to polish the upper and lower both main surfaces with a double side polishing machine using a polishing slurry containing an abrasive and a polishing pad made of a foamed resin or the like (hard polishing pad or soft polishing pad).

[0038]

As the abrasive, silica particles, alumina particles, zirconia particles, zircon particles, cerium oxide particles, manganese oxide particles, and the like can be used. For example, the polishing (primary polishing) can be conducted using the abrasive having an average particle size of 0.3 to 5 μm . Only the primary polishing may be conducted but, after the primary polishing, secondary polishing may be conducted using an abrasive having a smaller particle size. Moreover, after the secondary polishing,

tertiary polishing may be conducted using an abrasive having a further smaller particle size.

[0039]

<Precise cleaning Step>

5 In the precise cleaning step, for the glass substrate whose main surface is polished, for example, after scrub cleaning using a detergent is performed, ultrasonic cleaning in a state of being dipped in a detergent solution, ultrasonic cleaning in a state of being dipped in pure water, and the like are successively conducted. After the cleaning, drying is performed. As the drying method, there are, for example, vapor
10 drying with isopropyl alcohol vapor, hot-water hot-air drying with hot air, spin drying, and the like.

[0040]

 Through such respective steps, the glass substrate for a magnetic recording medium of the invention is obtained. The magnetic disk (magnetic recording medium)
15 has a structure that a magnetic layer, a protective layer, a lubricating film, and the like are provided on the main surface of the thus obtained glass substrate for a magnetic recording medium.

[0041]

 The magnetic layer may be a longitudinal recording type one or a
20 perpendicular recording type one but, particularly from the viewpoint of improving the recording density, the perpendicular recording type one is preferred.

 The magnetic layer for the perpendicular recording is a magnetic layer in which an easy axis of magnetization is in a perpendicular direction against the substrate surface and contains at least Co and Pt. In order to reduce an intergranular exchange
25 bond that causes a high inherent medium noise, it is suitable to form a well isolated fine

particle structure. Specifically, it is suitable to add an oxide (SiO_2 , SiO , Cr_2O_3 , CoO , Ta_2O_3 , TiO_2 , or the like), Cr, B, Cu, Ta, Zr, or the like to a CoPt-based alloy or the like.

[0042]

In the case of the perpendicular recording type one, it is common to dispose
5 a soft magnetic ground layer comprising a soft magnetic material, which plays a role of circulating a recording magnetic field from the magnetic head, as an underlying layer of the magnetic layer. In the soft magnetic ground layer, CoNiFe, FeCoB, CoCuFe, NiFe, FeAlSi, FeTa₂N, FeN, FeTaC, CoFeB, CoZrN, and the like can be used. Moreover, between the soft magnetic ground layer and the magnetic layer for
10 perpendicular recording, it is preferred to form a non-magnetic intermediate layer of Ru, an Ru alloy, or the like. The non-magnetic intermediate layer has a function of facilitating epitaxial growth of the magnetic layer for perpendicular recording and a function of interrupting the magnetic exchange bond between the soft magnetic ground layer and the magnetic layer for perpendicular recording.

[0043]

These magnetic layers of the soft magnetic ground layer, the non-magnetic intermediate layer, and the magnetic layer for perpendicular recording can be continuously formed by an in-line sputtering method, a DC magnetron sputtering method, and the like.

[0044]

In order to prevent the magnetic layer from corroding and prevent the medium surface from damaging at the time when the magnetic head comes into contact with the magnetic recording medium, a protective layer is provided on the magnetic layer. The protective layer can be formed using a material containing C, ZrO_2 , SiO_2 ,
25 or the like. As the forming method, an in-line sputtering method, a plasma CVD method, a spin-coating method, and the like can be used.

[0045]

In order to reduce friction between the magnetic head and the magnetic recording medium, a lubricating film is preferably formed on the surface of the protective film. The lubricating film comprises, for example, a perfluoropolyether, a
5 fluorinated alcohol, a fluorinated carboxylic acid, or the like and can be formed by a dipping method, a spraying method, or the like.

[Examples]

[0046]

The following will specifically describe Examples of the invention but the
10 invention should not be construed as being limited to Examples. Among the following Examples 1 to 13, Examples 1 to 8 are Working Examples of the invention and Examples 9 to 13 are Comparative Examples.

[0047]

Examples 1 to 13

15 The following steps were successively conducted to manufacture glass substrates for a magnetic recording medium.

[0048]

<Circular Processing Step>

A glass sheet containing SiO_2 as a main component and being made by a
20 float process was processed into a disk-shaped glass substrate having a circular hole at a center thereof so as to obtain a glass substrate for a magnetic recording medium having an outer diameter of 65 mm, an inner diameter of 20 mm, and a thickness of 0.635 mm.

[0049]

<Chamfering Step>

25 Intersecting parts of an inner peripheral side surface and upper and lower both main surfaces of the disk shaped glass substrate having a circular hole at a center

thereof and intersecting parts of an outer peripheral side surface and the upper and lower both main surfaces were chamfered so as to obtain a glass substrate for a magnetic recording medium having a chamfered width of 0.15 mm and a chamfered angle of 45° finally.

5 [0050]

<Primary Lapping Step of Main Surface>

Primary lapping of upper and lower both main surfaces of the glass substrate was conducted using a lapping slurry containing an alumina abrasive having an average particle size of 25 μm with a double side lapping machine (manufactured by
10 Speedfam Co., Ltd., product name: DSM-16B-5PV-4MH). After the primary lapping, the substrate was cleaned to remove the abrasive.

[0051]

In Examples 1 to 4, 7 to 8, and 12 to 13, two-step lapping was conducted. Namely, as shown in Table 1, after lapping was conducted for 8 or 7 minutes with
15 applying a low pressure of 2 or 3 kPa as main pressure in an early stage (first step), lapping was conducted at a pressure of 9 kPa for 15 minutes as main pressure in a second step. In Examples 5 to 6 and 9 to 11, as shown in Table 1, a pressure of 8 to 12 kPa was applied as main pressure for 16 to 22 minutes. In Examples 9 to 11 where the
20 processing pressure was high, since lapping was conducted in a state that the bad flatness of the glass substrate was corrected by the main pressure at the lapping, there was observed a so-called "spring back" phenomenon that the bad flatness came back when the lapping pressure was released after the lapping process.

[0052]

<Peripheral Surface Polishing Step>

25 The outer peripheral surface of the glass substrate was polished using a polishing brush and polishing slurry containing a cerium oxide abrasive to remove

scratches on the outer peripheral surface so as to obtain a mirror surface. After the polishing of the outer peripheral surface, the glass substrate was cleaned to remove the abrasive. Then, the inner peripheral surface of the glass substrate was polished using a polishing brush and polishing slurry containing a cerium oxide abrasive to remove scratches on the inner peripheral surface so as to obtain a mirror surface. After the polishing of the inner peripheral surface, the glass substrate was cleaned to remove the abrasive.

[0053]

<Secondary Lapping Step of Main Surface>

Using a fixed abrasive tool containing a diamond abrasive having an average particle size of 4 μm and a lapping slurry, the upper and lower both main surfaces of the glass substrate were lapped with a double side lapping machine (manufactured by Speedfam Co., Ltd., product name: DSM-16B-5PV-4MH). The lapping was conducted at a main pressure of 10kPa for 10 minutes.

[0054]

<Main Surface Polishing Step>

The both main surfaces of the glass substrate were polished with a double side polishing machine. The polishing included three-stage polishing of primary polishing, secondary polishing, and tertiary polishing (finish polishing).

[0055]

(Primary Polishing)

In the primary polishing step, the main surfaces of the glass substrate were polished with a 16B type double side polishing machine (manufactured by Speedfam Co., Ltd., product name: DSM-16B-5PV) using a polishing slurry containing a cerium oxide abrasive having an average particle size of 1.2 μm and a hard urethane polishing pad. One lot included 100 sheets. Moreover, groove depth formed on the polishing

pad surface and parallelism of polishing surfaces of upper and lower platens are shown in Table 1.

[0056]

In this regard, the polishing surfaces of the upper and lower platens were formed by dressing treatment where the surfaces of the polishing pads attached to the upper and lower platens of the polishing machine were lapped. With regard to the parallelism of the polishing surfaces (polishing surfaces of the polishing pads attached to the upper and lower platens) of the upper and lower platens, when a distance between the polishing surface of the upper platen and the polishing surface of the lower platen at the inner peripheral side of the upper and lower platens was taken as D1 and a distance between the polishing surface of the upper platen and the polishing surface of the lower platen at the outer peripheral side was taken as D2, an absolute value of (D2-D1) was taken as the parallelism.

[0057]

The above (D2-D1) was measured using a straightness meter (manufactured by Hitz High-Technology Corporation, product name: HSS-1700). As shown in Fig. 2, the value was obtained by placing the straight meter at the polishing surface 30a of the upper platen 30 and the polishing surface 40b of the lower platen 40 along the straight line X, scanning the meter so that a gauge head of the straightness meter passed through outer peripheries (X1 and X4) and inner peripheries (X2 and X3) of the polishing surfaces 30a and 40a, and measuring the shape of the polishing surface 30a of the upper platen 30 and the shape of the polishing surface 40a of the lower platen 40.

[0058]

In this regard, a cross-sectional views showing examples of the shapes of polishing surfaces of the upper and lower platens are shown in Figs. 3. Fig. 3A shows an example of a shape where the distance between the polishing surface 30a of the

upper platen 30 and the polishing surface 40a of the lower platen 40 is larger at the outer peripheral side than at the inner peripheral side. In this case, the value of (D2-D1) becomes positive. Fig. 3B shows an example of a shape where the distance between the polishing surface 30a of the upper platen 30 and the polishing surface 40a of the lower platen 40 is larger at the inner peripheral side than at the outer peripheral side. In this case, the value of (D2-D1) becomes negative. In either shape, the nearer to zero the absolute value of (D2-D1) is, the better the parallelism of the polishing surfaces of the upper and lower platens is.

[0059]

In the primary polishing step, the polishing was performed at a main polishing pressure of 8.5 kPa and a platen rotation number of 30 rpm for a polishing time set so as to obtain a total removal volume in a thickness direction of the both main surfaces of 40 μ m. After the primary polishing, the glass substrate was cleaned to remove the cerium oxide abrasive.

[0060]

In Examples 1 to 6 and 9 to 13, the polishing was conducted, as shown in Table 1, with controlling the groove depth of the polishing pad to 0.8 to 1.0 mm and a clearance between the hole diameter of polishing carrier and the outer diameter of the glass substrate to 1.7 mm. On the other hand, in Examples 7 to 8, the polishing was conducted, as shown in Table 1, with controlling the groove depth of the polishing pad to 0.1 to 0.2 mm and the clearance between the hole diameter of polishing carrier and the outer diameter of the glass substrate to 0.2 mm.

[0061]

(Secondary Polishing Step)

The both main surfaces of the glass substrate after the primary polishing were polished with the same both side polishing machine as in the primary polishing

using a polishing slurry containing a cerium oxide abrasive having an average particle size of 0.5 μm and a soft urethane polishing pad. In the secondary polishing step, the polishing was performed at a main polishing pressure of 9.5 kPa and a platen rotation number of 9 rpm for a polishing time set so as to obtain a total removal volume in a thickness direction of the both main surfaces of 5 μm . After the secondary polishing, the glass substrate was cleaned to remove the cerium oxide abrasive.

[0062]

(Tertiary Polishing Step)

The both main surfaces of the glass substrate after the secondary polishing were subjected to polishing (finish-polishing) with a 16B type double side polishing machine (manufactured by Speedfam Co., Ltd., product name: DSM-16B-5PV) using a polishing slurry containing colloidal silica having an average particle size of primary particles of 20 to 30 nm as a main component and a soft urethane polishing pad. In the tertiary polishing step, the polishing was performed for a polishing time set so as to obtain a total removal volume in a thickness direction of the upper and lower both main surfaces of 1 μm .

[0063]

<Precise Cleaning Step>

For the glass substrate after the tertiary polishing, scrub cleaning with a detergent, ultrasonic cleaning in a state of being dipped in a detergent solution, and ultrasonic cleaning in a state of being dipped in pure water were successively conducted. Then, the substrate was dried with isopropyl alcohol vapor.

[0064]

[Table 1]

Example	Primary lapping (loose abrasive lapping) step				Primary polishing step	
	First step		Second step		Polishing surface of upper and lower platens	Polishing pad surface (polishing surface)
	Main pressure [kPa]	Time [min]	Main pressure [kPa]	Time [min]	Parallelism [μm]	Groove depth [mm]
1	2	8	9	15	20	1.0
2	2	8	9	15	20	1.0
3	3	7	9	15	20	1.0
4	3	7	9	15	20	0.9
5	8	22			20	0.8
6	8	22			20	1.0
7	2	8	9	15	20	0.1
8	3	7	9	15	20	0.2
9	11	18			20	1.0
10	12	16			20	0.8
11	12	16			20	1.0
12	3	7	9	15	40	1.0
13	3	7	9	15	40	0.9

[0065]

Then, for the glass substrates for a magnetic recording medium obtained in Examples 1 to 13, the flatness of clamp area of the main surface, the thickness deviation in the clamp area, and the surface waviness of the clamp area were measured by the following methods. The measurement results are shown in Table 2. In these glass substrates for a magnetic recording medium, the clamp area of the main surface is an area from the circumference of a circle (concentric circle) having a diameter of 25.6 mm, which is concentric with the circular hole, to the inner peripheral part of the main surface.

[0066]

[Flatness of Clamp area]

Using an interferometric flatness meter (manufactured by Zygo Corporation, Ltd., Model; Zygo GI Flat (MESA)), the flatness of the clamp area of each of the both main surfaces of the glass substrate for a magnetic recording medium was measured by a phase-shift interferometry (phase shift method) using a light source

having a measuring wavelength of 680 nm. The flatness was measured at the clamp areas of the both main surfaces and better flatness was described in Table 2.

[0067]

[Thickness Deviation of Clamp area]

5 The thickness of the glass substrate was measured using a laser displacement gauge (manufactured by Keyence Co., Ltd., laser head: LK-G15, amplifier: LK-G3000V) at 4 positions having a central angle of 0°, 90°, 180° and 270° in total on a circumference of a radius of 12.8 mm from a center of the circular hole of the glass substrate. The difference between the maximum thickness value and the
10 minimum thickness value of the thickness values measured (4 positions) was determined and the value was shown in Table 2 as the thickness deviation of the clamp area.

[0068]

[Surface Waviness of Clamp area]

15 Using a white light interferometric shape measuring instrument (manufactured by ADE phaseshift Company, Model; Opti Flat), the surface waviness having a period of 500 μm to 5000 μm in the clamp area of the glass substrate for a magnetic recording medium was measured by an interferometry with a white light with setting a band path filter in the range of 500 μm to 5000 μm . Then, the surface
20 waviness amplitude value (PV value) that is a difference between the maximum peak height and the minimum valley depth of the surface waviness was determined. In this regard, the surface waviness was measured at each of the clamp areas of the both main surfaces and a higher PV value of the surface waviness was described in Table 2.

[0069]

25 Then, for the glass substrates obtained in Examples 1 to 13, the following measurement of the fluttering displacement and HDD shock resistance test were

conducted to measure properties as the glass substrate for a magnetic recording medium. The measurement results are shown in Table 2.

[0070]

[Fluttering Displacement]

5 The clamp area of the glass substrate for a magnetic recording medium was fastened and fixed to a spin stand (manufactured by Nano Test Company; air spindle) through a clamp member. The fixed glass substrate for a magnetic recording medium was rotated at a predetermined rotation number (7500 rpm) and the fluttering displacement was measured with a laser Doppler vibration meter (manufactured by Ono
10 Sokki Co., Ltd., body of the meter; LV-1720A, logger unit; AU4100, control/FFT analytical software; Repolyzer 2). In the case where the fluttering displacement is 40 nm or more, there is a concern that accuracy of writing and reading data is adversely affected or the head comes into contact with the disk surface when the glass substrate is mounted on HDD as a magnetic recording medium and reading and writing of signals
15 by a magnetic head is performed to the magnetic recording medium.

[0071]

[HDD Shock Resistance]

 After the clamp area of the glass substrate for a magnetic recording medium was fixed to a spindle part of 2.5 inch-type HDD with a clamp member through a
20 spacer, two sides of the side surfaces thereof were fixed to an aluminum platform of a drop-type shock testing machine in a state that the above HDD was maintained horizontal. Here, an acceleration sensor was placed on the aluminum platform and the machine was constituted so as to measure the shock of the dropping. Then, after HDD to which the glass substrate for magnetic recording medium had been fixed was dropped
25 10 times from the height from which an acceleration of 1100 G was to be imparted, it

was confirmed whether the glass substrate for magnetic recording medium was broken or not.

[0072]

Next, after magnetic recording media (for magnetic disk) was manufactured using the glass substrates for magnetic recording medium of Examples 1 to 13, a glide height test was conducted for evaluating the properties of the magnetic recording media.

[0073]

[Manufacture of Magnetic Recording Medium]

After the glass substrates for magnetic recording medium obtained in Examples 1 to 13 were subjected to precision cleaning to remove surface particles, a CoFeZrNb layer having a thickness of 150 nm as a soft magnetic layer, an Ru layer having a thickness of 10 nm as a non-magnetic intermediate layer, and a granular structure layer of CoCrPtB having a thickness of 15 nm as a magnetic layer for perpendicular recording were sequentially formed to stack in this order using a magnetron sputtering apparatus. Then, after an amorphous diamond-like carbon film having a thickness of 4 nm was formed on the magnetic layer for perpendicular recording method as a protective layer by a CVD method, a perfluoropolyether lubricating film was formed on the surface by a dipping method.

[0074]

[Glide Height Evaluation]

In the glide height evaluation, the relation between the magnetic head and the magnetic disk is reproduced using a head for inspection where a sensor for glide height test, such as a piezo element or an acoustic emission, is provided on a head slider. Then, when an abnormal protrusion and the like having a certain height or higher collides with the head slider of the test head, an over vibration energy generated thereby is detected to detect the presence of an abnormal protrusion at every recording

area in a certain range including a large number of tracks, which corresponds to the width of flying surface of the head slider, on the surface of the magnetic disk.

[0075]

The glide height evaluation was conducted as shown below. Namely, each
5 of the magnetic recording media manufactured using the glass substrates of Examples 1 to 13 was rotated at a rotation rate of 7200 rpm, the head for inspection having a flying height of 5 nm was run with flying on the magnetic recording medium, and it was confirmed whether hit (the head grazed a protrusion on the surface of the magnetic recording medium) or crash (the head collided a protrusion on the surface of the
10 magnetic recording medium) of the head for inspection was present or not.

[0076]

Then, the magnetic recording medium exhibiting no generation of the hit or crash of the head for inspection was taken as an accepted one and an acceptance rate (%) on the glide height evaluation was determined. The results of the glide height
15 evaluation are shown in table 2

[0077]

[Table 2]

Example	Evaluation of glass substrate for magnetic recording medium					Evaluation of magnetic recording medium
	Evaluation results of clamp area			Fluttering	HDD shock resistance	Glide height evaluation
	Flatness [μm]	Thickness deviation [μm]	Surface waviness amplitude value [nm]	Displacement [nm]	Crack generation rate [%]	Acceptance rate [%]
1	0.2	0.0	4.8	20	0	97
2	0.3	0.1	4.1	22	0	95
3	0.5	0.2	4.6	23	0	95
4	0.7	0.2	5.3	26	0	92
5	0.2	0.1	5.0	22	0	95
6	0.3	0.0	5.4	23	0	96
7	0.2	0.0	34.6	21	10	96
8	0.4	0.2	21.0	25	10	94
9	1.1	0.1	4.7	43	20	62
10	1.3	0.1	6.3	46	40	47
11	1.8	0.2	5.4	52	50	40
12	0.3	0.4	5.2	38	20	59
13	0.5	0.6	5.6	45	20	48

[0078]

As is understood from Table 1 and 2, in Examples 1 to 8, since the flatness of the clamp area is 1 μm or less and also the thickness deviation of the glass substrate in the clamp area is 0.3 μm or less in the main surface, the fluttering displacement is suppressed within a small range when each of the glass substrates for a magnetic recording medium is fastened and fixed on HDD with a clamp member and then rotated at a high speed. Moreover, the magnetic recording media manufactured using these glass substrates for a magnetic recording medium exhibit excellent properties in the glide height evaluation. It is considered that this is because the fluttering displacement decreases when the magnetic recording media are rotated at a high speed and the flying posture of the magnetic head is stabilized.

[0079]

Furthermore, in Examples 1 to 6, since the surface waviness amplitude value of the clamp area is decreased to be as extremely small as 20 nm or less, local stress concentration in the clamp area is relieved at the time when the shock of the drop or the like is imparted to HDD and, as a result, the shock resistance of the glass substrates is increased, so that the crack generation rate in the HDD shock resistance test of each of the glass substrates for a magnetic recording medium is 0%.

[0080]

On the other hand, in Examples 9 to 11, in at least one of the main surfaces, the flatness of the clamp area exceeds 1 μm . Moreover, in Examples 12 to 13, the thickness deviation of each of the glass substrates in the clamp area is a value which exceeds 0.3 μm . Therefore, in Examples 9 to 13, the fluttering displacement is large when each of these glass substrates is installed in HDD with fastening and fixing with a clamp member and is rotated at a high speed. Moreover, the magnetic recording media manufactured using these glass substrates for a magnetic recording medium exhibit low values of the acceptance rate on the glide height evaluation. Furthermore, the crack generation rate of each of the glass substrates for a magnetic recording medium in the HDD shock resistance test is also large.

[0081]

In Examples 1 to 6 and Examples 9 to 13, in the primary polishing step, since the polishing is conducted under conditions that the groove depth of the polishing pad is 0.8 to 1.0 mm and the clearance between the hole diameter of the polishing carrier and the outer diameter of the glass substrate is 1.7 mm, the circulation of the polishing slurry is good and the autorotation of the glass substrate in the polishing carrier hole is sufficiently achieved, so that it is considered that uniform polishing is effected and waviness on the main surface of the glass substrate is decreased.

On the other hand, in Examples 7 to 8, since the polishing is conducted under conditions that the groove depth of the polishing pad is 0.1 to 0.2 mm and the clearance between the hole diameter of the polishing carrier and the outer diameter of the glass substrate is 0.2 mm, the polishing is conducted in a state that the circulation of the polishing slurry is insufficient and the autorotation of the glass substrate in the polishing carrier hole is not easily achieved, so that it is considered that uniform polishing is not effected and there is generated a area where surface waviness is locally increased from a part of the inner peripheral part to the inside of the main surface of the glass substrate.

[0082]

The present application is based on Japanese Patent Application No. 2011-255069 filed on November 22, 2011, and the contents are incorporated herein by reference.

[Industrial Applicability]

[0083]

According to the glass substrate for a magnetic recording medium of the present invention, in the case where the glass substrate is mounted on a magnetic disk device, there can be provided a magnetic disk device which prevents troubles such as a head crash to be generated on HDD, improves shock resistance of the magnetic recording medium, and is capable of increasing recording density and highly reliable.

[Description of the Reference Numerals]

[0084]

10 ... Glass substrate for magnetic recording medium,

11 ... Circular hole,

101 ... Inner peripheral side surface,

102 ... Outer peripheral side surface,

	103 ... Main surface,
	104 ... Chamfered part,
	105 ... Clamp area,
	30 ... Upper platen,
5	40 ... Lower platen.

[Designation of Document] Claims

[Claim 1]

A glass substrate for a magnetic recording medium, having a disk shape, having a circular through hole at a center thereof and having one pair of main surfaces facing to each other,

wherein, in the main surfaces, a clamp area including a position to be fastened with a fastening member at the time when the magnetic recording medium is fixed to a hard disk drive has a flatness of 1 μm or less and a thickness deviation of 0.3 μm or less.

[Claim 2]

The glass substrate for a magnetic recording medium according to claim 1, wherein the flatness is 0.7 μm or less.

[Claim 3]

The glass substrate for a magnetic recording medium according to claim 2, wherein the flatness is 0.5 μm or less.

[Claim 4]

The glass substrate for a magnetic recording medium according to any one of claims 1 to 3, wherein, in the main surfaces, the clamp area has a surface waviness amplitude value of 20 nm or less.

[Claim 5]

The glass substrate for a magnetic recording medium according to claim 4, wherein the surface waviness amplitude value is 10 nm or less.

[Claim 6]

The glass substrate for a magnetic recording medium according to any one of claims 1 to 5, wherein the thickness deviation is 0.2 μm or less.

[Claim 7]

The glass substrate for a magnetic recording medium according to any one of claims 1 to 6, wherein the clamp area is, in the main surfaces, a ring area present at a central side from a circumference of a circle which has a diameter being 128% of a diameter of the circular through hole and which is concentric with the circular through hole.

[Claim 8]

A magnetic recording medium using the glass substrate for a magnetic recording medium according to any one of claims 1 to 7.