

DESCRIPTION

[Title of Invention]

GLASS SUBSTRATE FOR INFORMATION RECORDING MEDIUM AND
MAGNETIC DISK DEVICE

5 [Technical Field]

[0001] The present invention relates to a glass substrate for an information
recording medium and a magnetic disk device.

[Background Art]

[0002] Conventionally, an aluminum substrate or a glass substrate has been
10 used in an information recording medium (magnetic-disk recording medium) to
be used in a computer or the like. A magnetic thin film layer is formed on the
substrate and magnetized with a magnetic head, resulting in information being
recorded in the magnetic thin film layer.

[0003] In recent years, magnetic disk devices such as hard disk (HDDs) devices
15 that are provided in computers or the like and have a storage capacity of 500 GB
(250 GB per surface) and an areal recording density of 630 Gbit/in² or more per
2.5-inch recording medium have been developed.

[0004] Following such an increase in recording density, a gap (flying height)
between the information recording medium and the magnetic head that reads
20 and writes records while flying above the information recording medium has
decreased.

[0005] As the flying height decreases, the magnetic head and the information recording medium are more likely to come into contact with each other (also referred to as head crash) due to minute protrusions and recessions formed on a main surface of the glass substrate. In order to suppress head crash, the requirements on the smoothness and flatness of the main surface of the glass substrate have been increasing.

[0006] For example, JP 2008-234823A (Patent Literature 1) is given as a document that discloses a glass substrate for an information recording medium with which head crash can be suppressed by improving the flatness of the main surface of the glass substrate.

[0007] The glass substrate for an information recording medium disclosed in Patent Literature 1 includes a deviation portion that deviates from a reference flat plane obtained with reference to a flat surface other than a circumferential end portion of the main surface due to protrusion or recession from the reference flat plane, at the circumferential end portion of the main surface, and the deviation portion is formed such that the size of the deviation portion that deviates from the reference flat plane (deviation amount) of the deviation portion is substantially uniform over the entire circumference of the glass substrate on one main surface.

[CitationList]

[PatentLiterature]

[0008] [PLT1]:JP2008-234823A

[SummaryofInvention]

[TechnicalProblem]

[0009] In order to increase the recording density of a HDD to 630 Gbit/in² or
5 more, a DFH (Dynamic Flying Height) mechanism for adjusting the gap between
the magnetic head and the information recording medium is used. In the case
where the DFH mechanism is adopted, it is possible to reduce the flying height to
3 nm or less.

[0010] In general, in the case where the information recording medium is rotated
10 ata high speed in the magnetic disk device, the circumferential speed of the
information recording medium is increased particularly in the outer
circumferential edge portion, and thus the head is likely to fly due to the
influence of air flow (air force) occurring in the vicinity of the outer
circumferential edge portion.

15 [0011] In the case where the flying height is 3 nm or less, the magnetic head is
easily influenced significantly by air force in the vicinity of the outer
circumferential edge portion and the flying characteristics of the magnetic
head tend to become unstable. There are cases where a magnetic head is
disposed on both surfaces of the information recording medium instead of on only
20 one surface. In such a case, variation occurs in the air force occurring on the front
side and the back side due to a difference in the surface shapes of both surfaces of

the information recording medium, and the flying characteristics of the magnetic head are likely to be more unstable.

[0012] With the glass substrate disclosed in Patent Literature 1, sufficient consideration is not given to the flying characteristics of the magnetic head in the case where the magnetic thin film layers are formed on both main surfaces of the glass substrate and the magnetic heads are disposed on both sides of the glass substrate.

[0013] An object of the present invention is to provide a glass substrate for an information recording medium and a magnetic disk device including the same according to which it is possible to suppress turbulence of air flow resulting from the shape of a region in the vicinity of the outer circumferential edge portion of the information recording medium, and to stabilize the flying characteristics of the magnetic head.

[Solution to Problem]

[0014] A glass substrate for an information recording medium based on the present invention is to be used in an information recording medium on which a magnetic recording layer having a recording density of 630 Gbit/in² or more is formed and has a rotation center, and the glass substrate includes main surfaces that are respectively located on a front side and a back side of the glass substrate for an information recording medium, and an outer circumferential edge surface that is located in an outer circumferential edge portion of the glass substrate for

an information recording medium. In a case where a radius of the glass substrate for an information recording medium from the rotation center to the outer circumferential edge surface is R , and on both the front side and the back side, points on the main surfaces that are located $0.71R$ apart from the rotation center along a diameter direction are first reference points, points on the main surfaces that are located $0.83R$ apart from the rotation center along the diameter direction are second reference points, linear lines connecting the first reference points and the second reference points are reference lines, points on the reference lines that are located $0.99R$ apart from the rotation center are reference positions, and distances from points located on the main surfaces that coincide with the reference positions when viewed in an extending direction of a rotation axis passing through the rotation center, to the reference positions are deviation amounts, on both the front side and the back side, differences between maximum values and minimum values of distributions of the deviation amounts in the circumferential direction at radius positions located $0.99R$ apart from the rotation center are 40 nm or less, and a difference between an average value of the distribution of the deviation amounts in the circumferential direction on the front side and an average value of the distribution of the deviation amounts in the circumferential direction on the back side is 10 nm or less.

[0015] It is preferable that in the glass substrate for an information recording medium based on the present invention, the average value of the distribution of

the deviation amounts in the circumferential direction is 150 nm or less on both the front side and the back side.

[0016] It is preferable that in the glass substrate for an information recording medium based on the present invention, a thickness of the glass substrate for an information recording medium is 0.65 mm or less.

[0017] In an aspect of a magnetic disk device based on the present invention, a plurality of the glass substrates for an information recording medium are provided so as to have the same rotation axis.

[0018] In another aspect of a magnetic disk device based on the present invention, one or more said glass substrates for an information recording medium are rotated at a rotation rate of 7200 rpm or more.

[Advantageous Effects of the Invention]

[0019] According to the present invention, it is possible to provide a glass substrate for an information recording medium and a magnetic disk device including the same with which turbulence of air flow caused by the shape of a region in the vicinity of the outer circumferential edge portion of the information recording medium can be suppressed and the flying characteristics of the magnetic head can be stabilized.

[Brief Description of Drawings]

[0020] FIG. 1 is a schematic perspective view showing a magnetic disk device provided with a glass substrate for an information recording medium according to

an embodiment of the present invention.

FIG. 2 is a cross-sectional view showing a modified example of a magnetic disk device shown in FIG. 1.

FIG. 3 is a schematic diagram showing an information recording medium including the glass substrate for an information recording medium according to the embodiment of the present invention.

FIG. 4 is a schematic diagram showing a glass substrate for an information recording medium according to the embodiment of the present invention.

FIG. 5 is a cross-sectional view taken along line V-V shown in FIG. 4.

FIG. 6 is a diagram showing the distribution of deviation amounts in the circumferential direction on the back side of the glass substrate for an information recording medium shown in FIG. 5.

FIG. 7 is a diagram showing the distributions of deviation amounts in the circumferential direction on the front side and the back side of the glass substrate for an information recording medium shown in FIG. 5.

FIG. 8 is a flowchart showing a method for manufacturing a glass substrate for an information recording medium shown in FIG. 4. FIG. 9 is a side view of a double-side polishing device used in a second polishing step shown in FIG. 8.

FIG. 10 is a vertical cross-sectional view taken along line X-X shown in FIG. 9.

FIG. 11 is a cross-sectional view showing a situation in which the double-sidepolishing device shown in FIG. 9 is performing polishing processing.

5 FIG. 12 is a diagram showing how the glass substrate for an information recording medium shown in FIG. 4 is used, as an example.

FIG. 13 is a cross-sectional view showing a situation in which the double-sidepolishing device is performing precision polishing processing in the second polishing step when the glass substrate for an information recording
10 medium according to a comparative embodiment is manufactured.

FIG. 14 is a diagram showing a region surrounded by line XIV shown in FIG. 13.

FIG. 15 is a diagram showing a region surrounded by line XV shown in FIG. 13.

15 FIG. 16 is a diagram showing the distributions of deviation amounts in the circumferential direction on the front side and the back side of the glass substrate for an information recording medium in Comparative Example 1.

FIG. 17 is a diagram showing the distributions of deviation amounts in the circumferential direction on the front side and the back side of the glass
20 substrate for an information recording medium in Comparative Example 2.

FIG. 18 is a diagram showing the distributions of deviation amounts in the circumferential direction on the front side and the back side of the glass substrate for an information recording medium in Comparative Example 3.

FIG. 19 is a diagram showing conditions and results of a first experiment
5 performed to verify the effects of the present invention.

FIG. 20 is a diagram showing conditions and results of a second experiment performed to verify the effects of the present invention.

[Description of Embodiments]

[0021] Hereinafter, an embodiment of the present invention will be described in
10 detail with reference to the drawings. It should be noted that in the embodiment shown below, the same reference numerals are used to denote portions that are the same or used in common, and description thereof is not repeated.

[0022] (Embodiment)

FIG. 1 is a schematic perspective view showing a magnetic disk device
15 provided with a glass substrate for an information recording medium according to this embodiment. A magnetic disk device 100 provided with a glass substrate 1G for an information recording medium according to the present embodiment will be described with reference to FIG. 1.

[0023] As shown in FIG. 1, the magnetic disk device 100 includes an information
20 recording medium 10, an actuator 20, a housing 30, a clamping member 27, and a fixing screw 28.

[0024] The actuator 20 has a head slider 21, a suspension 22, an arm 23, a vertical shaft 24, a voice coil 25, and a voice coil motor 26. A spindle motor (not shown) is installed on the upper surface of the housing 30.

[0025] The information recording medium 10 such as a magnetic disk formed by
5 applying a magnetic material to the glass substrate 1G for an information recording medium (also referred to as a "glass substrate 1G" hereinafter) is fixed rotatably to the spindle motor by the clamping member 27 and the fixing screw 28. The information recording medium 10 is manufactured by forming a magnetic thin film layer (magnetic recording layer) on the glass substrate 1G. The
10 information recording medium 10 is driven by the spindle motor so as to rotate in a DR1 direction about a rotation axis L1 passing through a rotation center CP (see FIG. 4) of the glass substrate 1G at a rotation rate of several thousand rpm, for example.

[0026] The arm 23 is attached swingably about the vertical shaft 24. The
15 suspension 22, which is formed to have a plate-spring (cantilever) shape, is attached to the end of the arm 23. The head slider 21 which includes a magnetic head (not shown), is attached to the end of the suspension 22 so as to sandwich the information recording medium 10.

[0027] The voice coil 25 is attached onto the side opposite to the head slider 21 of
20 the arm 23. The voice coil 25 is gripped by a magnet (not shown) provided on the housing 30. The voice coil motor 26 is constituted by the voice coil 25 and the

magnet.

[0028] A predetermined electric current is supplied to the voice coil 25. The arm 23 swings about the vertical shaft 24 due to the effect of an electromagnetic force generated by the electric current flowing through the voice coil 25 and the magnetic field of the magnet. The suspension 22 and the head slider 21 also swing in the direction of arrow AR1 due to swinging of the arm 23. The head slider 21 moves reciprocally in the radial direction of the information recording medium 10 on the surface and the back surface of the information recording medium 10. A magnetic head (not shown) provided in the head slider 21 performs seek operations.

[0029] While the seek operations are performed, the head slider 21 receives a floating force due to air flow occurring along with the rotation of the information recording medium 10. The head slider 21 travels above the surface of the information recording medium 10 at a given flying height, according to the balance between the floating force and the elastic force (pressing force) of the suspension 22. The magnetic head provided in the head slider 21 can record and reproduce information (data) in a predetermined track within the information recording medium 10.

[0030] The flying height at which the magnetic head provided in the head slider 21 flies above the surface of the information recording medium 10 is referred to as the "flying height". In the magnetic disk device 100 of the present embodiment,

the flying height is 3 nm or less. That is, the distance between the information recording medium 10 and the magnetic head in the thickness direction of the information recording medium 10 at the time of rotation of the information recording medium 10 is 3 nm or less.

5 [0031] FIG. 2 is a cross-sectional view showing a modified example of the magnetic disk device shown in FIG. 1. A magnetic disk device 100A serving as a modified example of the magnetic disk device 100 shown in FIG. 1 will be described with reference to FIG. 2.

[0032] As shown in FIG. 2, the magnetic disk device 100A differs from the
10 magnetic disk 100 in that two information recording media 10 are configured to be able to rotate, and specifically, in the magnetic disk device 100A, two information recording media 10 are fixed rotatably to the spindle motor 29 by two clamping members 27. At this time, the two information recording media 10 are provided to have the same rotation axis L1 passing through the rotation center
15 CP (see FIG. 4). Also, each of the two information recording media 10 is arranged to be sandwiched by two head sliders 21.

[0033] FIG. 3 is a schematic diagram showing an information recording medium including the glass substrate for an information recording medium according to the embodiment of the present invention. An information recording medium
20 including the glass substrate 1G for an information recording medium according to the present embodiment will be described with reference to FIG. 3.

[0034] As shown in FIG. 3, the information recording medium 10 includes a disk-shaped glass substrate 1G having a central hole 11, a magnetic thin film layer 16 (magnetic recording layer) formed on a main surface 14 on the front side of the glass substrate 1G, and a magnetic thin film layer 17 (magnetic recording layer) formed on a main surface 15 on the back side of the glass substrate 1G.

[0035] The magnetic thin film layers 16 and 17 are formed by spin coating the main surface 14 on the front side of the glass substrate 1G and the main surface 15 on the back side thereof with a thermosetting resin in which magnetic particles are dispersed (spin coating method). The magnetic thin film layers 16 and 17 may be formed using a sputtering method, an electroless plating method, or the like.

[0036] The film thickness of each of the magnetic thin film layers 16 and 17 is approximately 0.3 μm to approximately 1.2 μm in the case of the spin coating method, approximately 0.04 μm to approximately 0.08 μm in the case of the sputtering method, and approximately 0.05 μm to approximately 0.1 μm in the case of the electroless plating method.

[0037] Co-based alloy in which Co having high crystalline anisotropy is used as a base and to which Ni or Cr is added to adjust the residual magnetic flux density may be used as a magnetic material to be used to form the magnetic thin film layers 16 and 17. A FePt-based material may be used as a magnetic material that is preferable to thermally assisted recording.

[0038] In order to improve sliding with respect to the magnetic heads, the surfaces of the magnetic thin film layers 16 and 17 may be coated with a thin lubricant. An example of the lubricant is a lubricant obtained by diluting perfluoropolyether (PFPE), for example, with a Freon-based solvent or the like. A base layer or a protecting layer may be provided as needed.

[0039] The base layer is selected in accordance with the type of magnetic film. Examples of material of the base layer include at least one or more materials selected from nonmagnetic metals such as Cr, Mo, Ta, Ti, W, V, B, Al, and Ni. The base layer may have a single layer structure, or may have a multiple layer structure in which the same type or different types of layers are stacked. Examples of the multiple layer structure include Cr/Cr, Cr/CrMo, Cr/CrV, NiAl/Cr, NiAl/CrMo, and NiAl/CrV.

[0040] Examples of the protecting layer preventing abrasion and corrosion of the magnetic thin film layers 16 and 17 include a Cr layer, a Cr alloy layer, a carbon layer, a hydrogenated carbon layer, a zirconia layer, and a silica layer. These protecting layers can be formed in succession along with the base layer, the magnetic film, and the like, with an in-line sputtering device. These protecting layers may have a single layer structure, or may have a multiple layer structure in which the same type or different types of layers are stacked.

[0041] Another protecting layer may be formed on the above-described protecting layer, or instead of the above-described protecting layer. For example, instead of

the above-described protecting layer, colloidal silica minute particles may be dispersed in a mixture obtained by diluting tetraalkoxysilane with an alcohol-based solvent, the resulting mixture may be applied onto the Cr layer and then burned so as to form a layer of silicon oxide (SiO_2) thereon.

5 [0042] FIG. 4 is a schematic diagram showing a glass substrate for an information recording medium according to the embodiment of the present invention. FIG. 5 is a cross-sectional view taken along line V-V shown in FIG. 4. The glass substrate 1G for an information recording medium according to the present embodiment will be described with reference to FIGS. 4 and 5.

10 [0043] As shown in FIGS. 4 and 5, the glass substrate 1G has main surfaces 14 and 15 located respectively on the front side and the back side thereof, an inner circumferential edge surface 13 defining a central hole 11, and an outer circumferential edge surface 12 located in the outer circumferential edge portion of the glass substrate 1G.

15 [0044] The main surfaces 14 and 15 include flat portions 14a and 15a extending in the diameter direction and the circumferential direction from the side of the inner circumferential edge surface 13, and inclined portions 14b and 15b that are located at the circumferential ends (in the vicinity of the outer circumferential edge portion) of the main surfaces, which are located outside of the flat portions
20 14a and 15a, and that are inclined so as to approach a center 12c of the outer circumferential edge surface 12 as they extend toward the outer side. Also,

chamfered portions 14c and 15c are provided between the inclined portions 14b and 15b and the outer circumferential edge surface 12.

[0045] The glass substrate 1G has a size of 0.8 inches, 1 inch, 1.8 inches, 2.5 inches, or 3.5 inches, for example. The glass substrate 1G has a thickness of 0.3 mm, 0.65 mm, 0.8 mm, 1 mm, 2 mm, or 2.2 mm, for example. The thickness of the glass substrate 1G is a value calculated by averaging values measured at a plurality of points that are point-symmetrical on the glass substrate 1G.

[0046] There is no particular limitation on the glass composition of the glass substrate 1G as long as it can be chemically strengthened by ion exchange. For example, soda-lime glass containing SiO_2 , Na_2O , and CaO as main components, aluminosilicate glass containing SiO_2 , Al_2O_3 , R_2O ($\text{R}=\text{K}$, Na , Li) as main components, borosilicate glass, Li_2O - SiO_2 -based glass, Li_2O - Al_2O_3 - SiO_2 -based glass, $\text{R}'\text{O}$ - Al_2O_3 - SiO_2 -based glass ($\text{R}'=\text{Mg}$, Ca , Sr , Ba) or the like can be used. Among these, aluminosilicate glass containing SiO_2 in an amount of 63 to 70 mol%, and containing SiO_2 and Al_2O_3 in a total amount of 70 mol% or more is preferable.

[0047] Here, the radius of the glass substrate 1G from the rotation center CP of the glass substrate 1G to the outer circumferential edge surface 12 is R in the present embodiment. Definitions are as follows. Points R1 on the main surfaces 14 and 15 that are located 0.71R apart from the rotation center along the diameter direction on both the front side and the back side are first reference points. Points

R2 on the main surfaces 14 and 15 that are located $0.83R$ apart from the rotation center along the diameter direction are second reference points. Linear lines BL connecting the first reference points and the second reference points are reference lines. Points R3 on the reference lines that are located $0.99R$ apart from the rotation center CP along the diameter direction are reference positions. Distances L from points R4 located on the main surfaces 14 and 15 (more specifically, inclined portions 14b and 15b) that coincide with the reference positions when viewed in the extending direction of the rotation axis L1 passing through the rotation center CP, to the above-described reference positions are deviation amounts.

[0048] The above-described inclined portions 14b and 15b are formed mainly in a second polishing step, which will be described later, and have minute protrusions and recessions in the circumferential direction. The deviation amounts in the inclined portions 14b and 15b have a slight distribution in the circumferential direction.

[0049] Although the present embodiment will be described taking, as an example, a case where the inclined portions 14b and 15b have a roll off shape in which the inclined portions 14b and 15b are recessed with respect to the above-described reference lines, the present embodiment is not limited to this, and may have a ski jump shape in which the inclined portions 14b and 15b protrude with respect to the reference lines. In this case as well, the reference

positions, points R4, deviation amounts, and the like can be defined similarly to the above. The deviation amount means a depth by which the inclined portion is recessed with respect to the reference line, or a height at which the inclined portion protrudes with respect to the reference line.

5 [0050] FIG. 6 is a diagram showing the distribution of deviation amounts in the circumferential direction on the back side of the glass substrate for an information recording medium shown in FIG. 5. FIG. 7 is a diagram showing the distribution of deviation amounts in the circumferential direction on the front side and the back side of the glass substrate for an information recording medium
10 shown in FIG. 5. The deviation amounts of the glass substrate 1G according to the present embodiment will be described with reference to FIGS. 6 and 7.

[0051] As shown in FIG. 6, a distribution 42 of deviation amounts in the circumferential direction at the radius position located $0.99R$ apart from the rotation center CP along the diameter direction on the back side of the glass
15 substrate 1G includes a point P2 indicating the maximum value and a point V2 indicating the minimum value. The position having the maximum deviation amount corresponds to a position located the farthest from the reference line, and the position having the minimum deviation amount corresponds to a position located the closest to the reference line. The difference between the maximum
20 value and the minimum value is the PV value. Also, an average value 42a of the distribution 42 of the deviation amounts in the circumferential direction is

indicated by a broken line.

[0052] Air flow occurring in the vicinity of the outer circumferential edge portion of the information recording medium 10 when the information recording medium 10 produced using the glass substrate 1G is rotated at a high speed is influenced
5 by not only the shape of the main surface on one side (frontside) but also the shape of the main surface on the other side (back side). Therefore, it is preferable that the main surfaces on the front side and the back side are as identical as possible. A difference in the shapes of the main surfaces on the front side and the back side can be checked using the difference between the above-described
10 average values on the front side and the back side as an index.

[0053] Specifically, as shown in FIG. 7, the difference between an average value 41a of a distribution 41 of deviation amounts in the circumferential direction at the radius position (0.99R position) on the front side of the glass substrate 1G and an average value 42a of a distribution 42 of deviation amounts in the
15 circumferential direction at the radius position (0.99R position) on the back side of the glass substrate 1G is used as the index.

[0054] As shown in FIGS. 6 and 7, the glass substrate 1G according to the present embodiment has a configuration such that the PV values (the difference between the maximum value and the minimum value) on the front side and the
20 back side are 40 nm or less at the radius position, and the difference between the average value 41a of the distribution 41 of deviation amounts in the

circumferential direction on the front side and the average value 42a of the distribution of deviation amounts in the circumferential direction on the back side is 10 nm or less.

[0055] With such a configuration, in the case where magnetic heads are disposed on the front side and the back side of the information recording medium 10 and the information recording medium 10 is rotated at a high speed, the distance between the magnetic head and the main surface including the above-described inclined portion can be made substantially uniform in the circumferential direction in the vicinity of the outer circumferential edge portion of the information recording medium. Accordingly, it is possible to suppress variation in air flow (air force) occurring on the front side and the back side of the information recording medium in the vicinity of the outer circumferential edge portion, and to stabilize the flying characteristics of the magnetic head. It is possible to improve the durability against fluttering and other disturbances (vibration, sound) in which the information recording medium 10 itself vibrates in the direction perpendicular to the rotation direction due to high speed rotation, and accordingly to stabilize the flying characteristics of the magnetic head.

[0056] Furthermore, it is preferable that the difference between the average value of the distribution of deviation amounts in the circumferential direction on the front side and the average value of the distribution of deviation amounts in the circumferential direction on the back side is 5 nm or less. In this case, it is

possible to suppress variation in the air flow and to further stabilize the flying characteristics.

[0057] Also, with the glass substrate 1G according to the present embodiment, the average values of deviation amounts on the front side and the back side are 150 nm or less. Making the deviation amount itself smaller in this manner can also further stabilize the flying characteristics.

[0058] It should be noted that although a case where the glass substrate 1G has a thickness of 0.3 mm, 0.65 mm, 0.8 mm, 1 mm, 2 mm, or 2.2 mm has been described as an example above, it is particularly preferable that the glass substrate 1G has a thickness of 0.65 mm or less. In the case where the thickness of the glass substrate is reduced and the fluttering amount of the glass substrate itself increases (in the case where the fluttering amount when the thickness is 0.635 mm is two times the fluttering amount when the thickness is 0.8 mm, for example), the above-described configuration makes it possible to significantly improve the above-described durability and reliably stabilize the flying characteristics of the magnetic head.

[0059] FIG. 8 is a flowchart showing a method for manufacturing a glass substrate for an information recording medium shown in FIG. 4. A method for manufacturing a glass substrate 1G according to the present embodiment will be described with reference to FIG. 8.

[0060] As shown in FIG. 8, the manufacturing method includes steps S10 to S19. First, a glass material is melted in a glass melting step S10. Next, the molten glass material is press-molded using an upper mold and a lower mold in a molding step S11. A glass substrate is obtained by molding. The glass substrate may be produced by cutting plate glass. The glass substrate is composed of aluminosilicate glass, for example.

[0061] Next, both main surfaces on the front side and the back side of the glass substrate are subjected to lapping processing using a double-side lapping device having a planetary gear mechanism in a first lapping step S12. Lapping surface plates are pressed against the glass substrate in the up and down direction, and the glass substrate and the lapping surface plates are moved relative to each other while the abrasive particles and a grinding liquid are supplied to both main surfaces of the glass substrate. Alumina or the like is used as the abrasive particles. A glass substrate having a substantially flat surface shape can be obtained by lapping processing.

[0062] Next, a central hole is formed in the central portion of the glass substrate using a cylindrical diamond drill in a coring step S13. Chamfering processing is performed on the inner circumferential edge surface and the outer circumferential edge surface of the glass substrate using a diamond grindstone. Next, lapping processing, which is similar to that in the first lapping step S12, is performed on both main surfaces of the glass substrate in a second

lapping step S14. Accordingly, minute protrusions and recessions formed on both main surfaces are removed.

[0063] Next, mirror-polishing processing is performed on the outer circumferential edge surface and the inner circumferential edge surface of the glass substrate using a brush in an outer circumference/inner circumference polishing step S15. A slurry containing cerium oxide abrasive particles as the polishing abrasive particles, for example, is used.

[0064] Next, both main surfaces of the glass substrate are polished using a double-side polishing device having a planetary gear mechanism in a first polishing step S16. Cerium oxide abrasive particles having an average particle diameter of approximately 1 μm , for example, is used as the polishing abrasive. Marks and warping remaining on both main surfaces are corrected in first and second lapping steps (S12, S14).

[0065] Next, compressive stress layers are formed on both main surfaces of the glass substrate in a chemical strengthening step S17. A solution in which potassium nitrate (70%) and sodium nitrate (30%) are mixed is heated to 300°C, and the glass substrate is then immersed in the mixture solution for approximately 30 minutes. The compressive stress layer is formed and both main surfaces and both edge surfaces of the glass substrate are strengthened.

[0066] Next, precision polishing processing is performed on both main surfaces of the glass substrate using a double-side polishing device having a planetary gear

mechanism in a second polishing step S18. Colloidal silica having an average particle diameter of approximately 20 nm, for example, is used as the polishing abrasive. Minute defects and the like remaining on both main surfaces are removed, and thus both main surfaces are finished to mirror surfaces. Minute warping is also removed and the both main surfaces have desired flatness. The second polishing step S18 will be described later in detail with reference to FIGS. 9 to 11.

[0067] Next, both main surfaces and both edge surfaces of the glass substrate are cleaned in a final cleaning step S19 and the glass substrate is then dried as appropriate. A method for manufacturing a glass substrate for an information recording medium in the present embodiment is configured as described above. By using this method for manufacturing a glass substrate, the glass substrate 1G shown in FIG. 4 can be obtained. As described above, the information recording medium 10 shown in FIG. 3 is obtained by forming a magnetic thin film layer on the glass substrate 1G.

[0068] FIG. 9 is a side view of a double-side polishing device used in the second polishing step shown in FIG. 8. FIG. 10 is a vertical cross-sectional view taken along line X-X shown in FIG. 9. FIG. 11 is a cross-sectional view showing a situation in which the double-side polishing device shown in FIG. 9 is performing precision polishing processing. The second polishing step S18 will be described in detail with reference to FIGS. 9 to 11.

[0069] As shown in FIG. 9, a double-sidepolishing device 200 includes an upper surface plate 210, an upper polishing pad 211, a lower surface plate 220, and a lower polishing pad 221. The upper surface plate 210 and the lower surface plate 220 have a columnar shape. The upper polishing pad 211 is mounted on the lower surface of the upper surface plate 210, which faces the lower surface plate 220 (glass substrate side). The lower polishing pad 221 is mounted on the upper surface of the lower surface plate 220, which faces the upper surface plate 210 (glass substrate side). The lower surface of the upper surface plate 210 and the upper surface of the lower surface plate 220 are parallel to each other and rotate in mutually opposite directions.

[0070] The upper polishing pad 211 and the lower polishing pad 221 are processing members for performing precision polishing on both main surfaces of the glass substrate. Suede pads made of polyurethane, for example, are used as the upper polishing pad 211 and the lower polishing pad 221. The surface of the upper polishing pad 211 facing the lower surface plate 220 forms an upper polishing surface 212. The surface of the lower polishing pad 221 facing the upper surface plate 210 forms a lower polishing surface 222.

[0071] As shown in FIG. 10, a plurality of carriers 250 for polishing having a disk shape are disposed on the lower polishing surface 222. The carriers 250 each include a main body portion 251 having a plurality of circular holes, and a plurality of engaging teeth 252 are provided in the outer circumference of each of

the carriers 250. The thickness of the carriers 250 is 650 μm , for example.

[0072] The glass substrate 1G is disposed in a circular hole provided in a main body portion 251. The thickness of the glass substrate 1G that has not undergone the precision polishing processing is 810 μm , for example. A sun gear 230 is provided in the central portion of the lower surface plate 220. An internal gear 240 is provided coaxially to the sun gear 230 in the circumferential end portion of the lower surface plate 220. The sun gear 230 and the internal gear 240 are thicker than the carriers 250 in a direction parallel to the rotation axis of the sun gear 230.

[0073] In a state in which the carriers 250 are disposed between the sun gear 230 and the internal gear 240, engaging teeth 252 of the carriers 250 engage with both a tooth surface 232 of the sun gear 230 and a tooth surface 242 of the internal gear 240. The carriers 250 are rotated using the sun gear 230 and the internal gear 240. In the present embodiment, by the sun gear being driven so as to rotate, the carriers 250 revolve around the sun gear 230 while rotating.

[0074] As shown in FIG. 11, when the precision polishing processing is performed by the double-side polishing device 200, the glass substrate 1G is sandwiched between the upper polishing pad 211 and the lower polishing pad 221 in a state in which a ring member 260 is inserted between an inner circumferential surface 253 of the carriers 250 that defines a circular hole and the glass substrate 1G.

[0075] Specifically, in a state in which the glass substrate 1G is fitted into the ring member 260 having a thickness substantially equal to that of the glass substrate 1G, the glass substrate 1G is sandwiched between the upper polishing pad 211 and the lower polishing pad 221 at a position where the ring member is about several mm apart from the inner circumferential surface 253.

[0076] Next, a predetermined stress is applied by the upper surface plate 210 and the lower surface plate 220 to the glass substrate 1G in the thickness direction thereof, and thus the main surfaces on the front side and the back side of the glass substrate 1G are pressed against the upper polishing surface 212 and the lower polishing surface 222.

[0077] At this time, inserting the ring member 260 between the inner circumferential surface 253 and the glass substrate 1G as described above makes it possible to suppress depression of the upper polishing pad 211 and the lower polishing pad 221 in the vicinity of the outer circumferential edge portion of the glass substrate 1G. Accordingly, the circumferential ends of the main surfaces on the front side and the back side of the glass substrate 1G can be made flatter at the time of polishing, which will be described later.

[0078] In this state, while a polishing liquid of colloidal silica or the like is supplied, in this state, the upper polishing surface 212 is moved relative to the main surface of the glass substrate 1G on the front side, and the lower polishing surface 222 is moved relative to the main surface of the glass substrate 1G on the

back side.

[0079] The upper polishing surface 212 slides against the main surface on the front side of the glass substrate 1G, and thus the main surface on the front side of the glass substrate 1G is polished. Also, the lower polishing surface 222 slides
5 against the main surface on the back side of the glass substrate 1G, and thus the main surface on the back side of the glass substrate 1G is polished. In this manner, both main surfaces of the glass substrate 1G are polished simultaneously.

[0080] At this time, due to not being fixed in the circular hole, the ring member 260 and the glass substrate 1G can rotate in the circular hole. Accordingly, the
10 circumferential ends of the main surfaces on the front side and the back side of the glass substrate 1G can be made flatter.

[0081] Next, in order to make the shapes of the main surfaces on the front side and the back side approximately equal, the glass substrate 1G is inverted partway through polishing processing in the second polishing step, and the
15 polishing processing is performed again. In this manner, the precision polishing processing is performed in the second polishing step 18.

[0082] A resin made of an epoxy resin or the like, for example, can be adopted as the material for the carrier 250 and the ring member 260 so as not to make marks on the glass substrate 1G. Also, in the case where a resin having a lower hardness
20 than that of the glass substrate 1G is adopted as the material for the ring member 260, it is preferable to form a member made of a fluorine-based resin (e.g.,

DLC (diamond-like carbon)) for improving abrasion resistance on the main surfaces of the ring member 260.

[0083] FIG. 12 is a diagram showing how the glass substrate for an information recording medium shown in FIG. 4 is used, as an example. The use example of the glass substrate 1G will be described with reference to FIG. 12. A magnetic thin film layer is not depicted in FIG. 12.

[0084] In the case where the magnetic disk device shown in FIG. 2 is used, as shown in FIG. 12, two information recording media 10 are each disposed so as to be sandwiched by two head sliders 21. Magnetic heads (not shown) are disposed at the ends of the head sliders 21 so as to face the main surfaces on the front side and the back side of the information recording media 10.

[0085] In the case where four magnetic heads scan the two information recording media 10, the frequency of head crash is two times the case where two magnetic heads scan one information recording medium 10.

[0086] Even in such a case, use of a plurality of glass substrates 1G according to the present embodiment in which variation in surface shape is suppressed makes it possible to stabilize the flying characteristics of the magnetic heads and reduce the frequency of head crash.

Working Example

[0087] Hereinafter, a load/unload test performed to verify the effect of the present invention and the results thereof will be described.

[0088] When the load/unload test is performed, three glass substrates manufactured based on the method for manufacturing a glass substrate 1H (see FIG. 13) in a comparative embodiment, which will be described later, were prepared as Comparative Examples 1 to 3, and then magnetic disks were manufactured by forming magnetic film formation layers on these substrate. Also, two glass substrates 1G according to the embodiment were prepared as Working Example 1 and Working Example 2, and magnetic disks were manufactured by forming magnetic film formation layers thereon. A load/unload test in which loading/unloading is repeated 5 million times using 3 nm as the flying height at the time of head flying and 5400 rpm or 7200 rpm as the rotation rate of the magnetic disk was performed on these magnetic disks, and durability was evaluated until head crash occurred.

[0089] A magnetic disk in which head crash occurred before the number of cycles of load/unload operation reached 5 million in the load/unload test was determined as a product not satisfying the quality standard of the product and as "bad", and a magnetic disk in which head crash did not occur when the number of cycles of load/unload operation reached 5 million was determined as a product satisfying the quality standard of the product and as "fair". Moreover, the load/unload test was repeated, and a magnetic disk in which head crash did not occur when the rotation number reached 5 million in each of two tests was determined as a product that sufficiently satisfied the quality standard of the product and as

"good".

[0090] A glass substrate 1G having an outer diameter of 2.5 inches (63.5 mm) as the size of the substrate was used. The glass substrates 1G having a thickness of 0.8 mm and 0.65 mm were used. The distribution of the above-described deviation amounts in the circumferential direction was measured, where points R1 that are located 23 mm apart from the rotation center CP of the glass substrate 1G along the diameter direction are first reference points, points R2 that are located 27 mm apart from the rotation center CP along the diameter direction are second reference points, linear lines BL connecting the first reference points and the second reference points are reference lines, points R3 on the reference lines that are located 32.2 mm apart from the rotation center CP are reference positions, and the reference positions are radius positions.

[0091] The deviation amounts were measured using an optical surface analyzer (OSA) 7120 (available from KLA-Tencor Candela). This analyzer can find the surface shape of the glass substrate 1G by irradiating the entire main surfaces of the glass substrate 1G with laser light while rotating the glass substrate, and performing arithmetic processing based on the reflected light and scattered light received by an optical receiver of this analyzer.

[0092] With the glass substrate according to Working Example 1, among PV values of distributions of deviation amounts in the circumferential direction on two sides, namely, the front side and the back side, the greater PV value was 40

nm, and the difference between the average value of the distribution of deviation amounts in the circumferential direction on the front side and the average value of the distribution of deviation amounts in the circumferential direction on the back side was 10 nm (see FIGS. 19 and 20).

5 [0093] With the glass substrate according to Working Example 2, among PV values of distributions of deviation amounts in the circumferential direction on two sides, namely, the front side and the back side, the greater PV value was 30 nm, and the difference between the average value of the distribution of deviation amounts in the circumferential direction on the front side and the average value
10 of the distribution of deviation amounts in the circumferential direction on the back side was 5 nm (see FIGS. 19 and 20).

[0094] When compared to the glass substrate 1G according to the present embodiment, the glass substrates of Comparative Examples 1 to 3 differ in manufacturing method, and specifically, differ in the second polishing
15 step. Accordingly, in the glass substrates according to Comparative Examples 1 to 3, the main surfaces thereof differ in shape, and the glass substrates differ in distribution of deviation amounts, as will be described later. Hereinafter, a method for manufacturing a glass substrate in the comparative examples will be described.

[0095] (Comparative embodiment)

FIG. 13 is a cross-sectional view showing a situation in which a double-sidepolishing device is performing precision polishing processing in the second polishing step, when the glass substrates for an information recording medium according to the comparative examples are manufactured. FIG. 14 is a diagram showing the region surrounded by line XIV shown in FIG. 13. FIG. 15 is a diagram showing the region surrounded by line XV shown in FIG. 13. The method for manufacturing a glass substrate according to the comparative embodiment will be described with reference to FIGS. 13 to 15.

[0096] When compared to the method for manufacturing the glass substrate 1G according to the embodiment, the method for manufacturing a glass substrate 1H according to the comparative embodiment differs in the second polishing step and the other steps are substantially similar to those of the embodiment.

[0097] The second polishing step of the method for manufacturing the glass substrate in the comparative embodiment is different from the second polishing step S18 of the method for manufacturing the glass substrate 1G according to the embodiment in that when the precision polishing processing is performed by the double-sidepolishing device 200, the ring member 260 (see FIG. 11) is not inserted between the inner circumferential surface 253 of the carrier 250 that defines the circular hole and the glass substrate 1H and the glass substrate 1H is not inverted partway through the second polishing step.

[0098] As shown in FIGS. 14 and 15, the main surfaces on the front side and the back side of the glass substrate 1H are pressed against the upper polishing surface 212 of the upper polishing pad 211 and the lower polishing surface 222 of the lower polishing pad 221 without inserting the ring member 260 (see FIG. 11), and thus as shown in FIGS. 14 and 15, the upper polishing pad 211 and the lower polishing pad 221 are depressed in the outer circumferential edge portion of the glass substrate 1H.

[0099] Accordingly, an inclined surface 211a (see FIG. 14) formed on the upper polishing pad 211 and an inclined surface 221b (see FIG. 15) formed on the lower polishing pad come into contact with the outer circumferential edge portion of the glass substrate 1H at the time of polishing. As a result, in the glass substrate in the comparative embodiment, the circumferential ends of the main surfaces on the front side and the back side are likely to be recessed or protrude.

[0100] Also, since the glass substrate 1H is not inverted partway through the second polishing step, the glass substrate 1H is easily influenced by the surface states of the upper polishing pad 211 and the lower polishing pad 221, and accordingly the circumferential ends of the main surfaces on the front side and the back side of the glass substrate 1H of the comparative embodiment are likely to be recessed or protrude.

[0101] FIGS. 16 to 18 are diagrams showing the distributions of deviation amounts in the circumferential direction on the front side and the back side of the

glass substrate 1H for an information recording medium in Comparative Examples 1 to 3. The distribution of deviation amounts of the glass substrates in Comparative Examples 1 to 3 in the case where each substrate has a thickness of 0.8 mm will be described with reference to FIGS. 16 to 18.

5 [0102] As shown in FIG. 16, with the glass substrate of Comparative Example 1 manufactured with the method for manufacturing a glass substrate in the comparative embodiment, both an average value 51a of a distribution 51 of deviation amounts in the circumferential direction on the front side and an average value 52a of a distribution 52 of deviation amounts in the circumferential
10 direction on the back side in the case where the reference positions are radius positions exceeded 150 nm.

[0103] Furthermore, among PV values of the distributions 51 and 52 of deviation amounts in the circumferential direction on two sides, namely the front side and the back side, the greater PV value was 60 nm, and the difference between the
15 average value 51a of the distribution 51 of deviation amounts in the circumferential direction on the front side and the average value 52a of the distribution 52 of deviation amounts in the circumferential direction on the back side was 30 nm (see FIG. 19).

[0104] As shown in FIG. 17, with the glass substrate of Comparative Example 2
20 manufactured with the method for manufacturing a glass substrate in the comparative embodiment, both an average value 53a of a distribution 53 of

deviation amounts in the circumferential direction on the front side and an average value 54a of a distribution 54 of deviation amounts in the circumferential direction on the back side in the case where the reference position is radius position exceeded 150 nm.

5 [0105] Furthermore, among PV values of the distributions 53 and 54 of deviation amounts in the circumferential direction on two sides, namely the front side and the back side, the greater PV value was 60 nm, and the difference between the average value 53a of the distribution 53 of deviation amounts in the circumferential direction on the front side and the average value 54a of the
10 distribution 54 of deviation amounts in the circumferential direction on the back side was 10 nm (see FIG. 19).

[0106] As shown in FIG. 18, with the glass substrate of Comparative Example 1 manufactured with the method for manufacturing a glass substrate in the comparative embodiment, both an average value 55a of a distribution 55 of
15 deviation amounts in the circumferential direction on the front side and an average value 56a of a distribution 56 of deviation amounts in the circumferential direction on the back side in the case where the reference positions are radius positions exceeded 150 nm.

[0107] Furthermore, among PV values of the distributions 55 and 56 of deviation
20 amounts in the circumferential direction on two sides, namely the front side and the back side, the greater PV value was 40 nm, and the difference between the

average value 55a of the distribution 55 of deviation amounts in the circumferential direction on the front side and the average value 56a of the distribution 56 of deviation amounts in the circumferential direction on the back side was 30 nm (see FIG. 19).

5 [0108] (Experiment Result)

FIG. 19 is a diagram showing the conditions and results of a first experiment performed to verify the effect of the present invention. The results of the first experiment that was performed to verify the effect of the present invention will be described with reference to FIG. 19.

10 [0109] In the first experiment that was performed to verify the effect of the present invention, substrates that had a thickness of 0.8 mm and in which PV values and differences between the average values of distributions of deviation amounts in the circumferential direction on the front side and the average values of distributions of deviation amounts in the circumferential direction on the back
15 side are values as those shown in FIG. 19 were used as Working Examples 1 and 2 and Comparative Examples 1 to 3. Also, the rotation rate of magnetic disks in the load/unload test were set to 5400 rpm or 7200 rpm.

[0110] Regarding Comparative Example 1, in the case where the rotation rate of the magnetic disk was 5400 rpm, head crash occurred at 1.2 million cycles,
20 whereas in the case where the rotation rate of the magnetic disk was 7200 rpm, head crash occurred at 1 million cycles, and the substrates were determined as

"bad" based on the above-described quality standard in both cases.

[0111] Regarding Comparative Example 2, in the case where the rotation rate of the magnetic disk was 5400 rpm, head crash occurred at 3.8 millioncycles, whereas in the case where the rotation rate of the magnetic disk was 7200 rpm, head crash occurred at 2.1 millioncycles, and the substrates were determined as "bad" based on the above-described quality standard in both cases.

[0112] Regarding Comparative Example 3, in the case where the rotation rate of the magnetic disk was 5400 rpm, head crash occurred at 4.0 millioncycles, whereas in the case where the rotation rate of the magnetic disk was 7200 rpm, head crash occurred at 3.9 millioncycles, and the substrates were determined as "bad" based on the above-described quality standard in both cases.

[0113] Regarding Working Example 1, in both the case where the rotation rate of the magnetic disk was 5400 rpm and the case where the rotation rate of the magnetic disk was 7200 rpm, head crash did not occur even when the number of cycles of load/unload operation reached 5 million, and the substrates were determined as "fair" based on the above-described quality standard.

[0114] Regarding Working Example 2, in both the case where the rotation rate of the magnetic disk was 5400 rpm and the case where the rotation rate of the magnetic disk was 7200 rpm, head crash did not occur even when the number of cycles of load/unload operation reached 5 million. Furthermore, in the cases of both above-described rotation rates, when a similar experiment is performed

repeatedly, head crash did not occur even when the number of cycles of load/unload operation reached 5 million twice, and the substrates were determined as "good" based on the above-described quality standard.

[0115] FIG. 20 is a diagram showing the conditions and results of a second experiment performed to verify the effect of the present invention. The results of the second experiment that was performed to verify the effect of the present invention will be described with reference to FIG. 20.

[0116] In the second experiment that was performed to verify the effect of the present invention, substrates that had a thickness of 0.65 mm and in which PV values and differences between the average values of the distributions of deviation amounts in the circumferential direction on the front side and the average values of the distributions of deviation amounts in the circumferential direction on the back side are the values shown in FIG. 20 were used as Working Examples 1 and 2 and Comparative Examples 1 to 3. Also, the rotation rate of the magnetic disks in the load/unload test was set to 5400 rpm.

[0117] Regarding Comparative Example 1, head crash occurred at 0.9 million cycles, and the substrate was determined as "bad" based on the above-described quality standard.

[0118] Regarding Comparative Example 2, head crash occurred at 1.9 million cycles, and the substrate was determined as "bad" based on the above-described quality standard.

[0119] Regarding Comparative Example 3, head crash occurred at 3.8 millioncycles, and the substrate was determined as "bad" based on the above-described quality standard.

[0120] Regarding Working Example 1, head crash did not occur even when the
5 number of cycles of load/unload operation reached 5 million, and the substrate was determined as "fair" based on the above-described quality standard.

[0121] Regarding Working Example 2, head crash did not occur even when the number of cycles of load/unload operation reached 5 million. Furthermore, when a similar experiment was performed repeatedly and the number of cycles of
10 load/unload operation reached 5 million, head crash did not occur, and the substrate was determined as "good" based on the above-described quality standard.

[0122] It can be said that it has been experimentally proved that, comparingWorking Examples 1 and 2 to Comparative Examples 1 to 3 in the first
15 experiment and the second experiment that were performed to verify the effect of the present invention, with Working Examples 1 and 2 satisfying the condition that a PV value is 40 nm or less and the difference between the average value on the front side and the average value on the back side is 10 nm or less, air flow was uniformized in the vicinity of the outer circumferential edge portion on the front
20 side and the back side, as a result of which the flying characteristics of the magnetic headbecame stable.

[0123] It can be said that it has been experimentally proved that, with Comparative Examples 1 to 3 that do not satisfy the condition that a PV value is 40 nm or less and the between the average value on the front side and the average value on the back side is 10 nm or less, air flow became non-uniform in the vicinity of the outer circumferential edge portion on the front side and the back side, as a result of which the flying characteristics of the magnetic head became unstable.

[0124] In Comparative Examples 1 to 3, the deviation amounts on the back surface side are substantially smaller than the deviation amounts on the front side (see FIGS. 16 to 18), and thus in the case where the magnetic heads are disposed in the vicinity of the outer circumferential edge portion of the information recording media on the front side and the back side, the main surface on the back surface side is closer to the magnetic head than the main surface on the front side is.

[0125] Therefore, air flow becomes non-uniform in the vicinity of the outer circumferential edge portion on the front side and the back side, and wind pressure in the vicinity of the outer circumferential edge portion on the back side is higher than the wind pressure in the vicinity of the outer circumferential edge portion on the front side. Therefore, it is conceivable that the magnetic head located in the vicinity of the outer circumferential edge portion on the back side having higher wind pressure is easily influenced by fluttering of the substrate

itself and other disturbances (vibration, sound) as well as wind pressure, as a result of which head crash is likely to occur.

[0126] It is conceivable that Working Examples 1 and 2 in which air flow is uniformized in the vicinity of the outer circumferential edge portion on the front side and the back side are unlikely to be influenced by fluttering of the substrate itself and other disturbances (vibration, sound) described above, and head crash is unlikely to occur.

[0127] Also, comparing the above-described first experiment to the above-described second experiment, in the case where the substrate thickness is reduced to 0.65 mm and the fluttering amount of the substrate itself increases, the number of cycles of load/unload operation at which head crash occurs is reduced due to an increase in the fluttering amount in Comparative Examples 1 to 3, and the durability decreases. On the other hand, with Working Examples 1 and 2, even in the case where the substrate thickness is reduced, head crash does not occur. Accordingly, it can be said that it has been experimentally proved that with the glass substrate according to the present embodiment, the lower the thickness is, the more reliably the flying characteristics of the magnetic head can be stabilized by uniformizing air flow in the vicinity of the outer circumferential edge portion on the front side and the back side of the glass substrate.

[0128] Also, comparing the case where the rotation rate is 5400 rpm to the case where the rotation rate is 7200 rpm in the above-described first experiment, in

the case where the rotation rate increases and the fluttering amount of the substrate itself increases more, in Comparative Examples 1 to 3, the number of cycles of load/unload operation at which head crash occurs decreases due to an increase in the fluttering amount, and the quality deteriorates. On the other hand, with Working Examples 1 and 2, even in the case where the rotation rate increases, head crash does not occur. Accordingly, it can be said that it has been experimentally proved that with the glass substrate according to the present embodiment, as the rotation rate increases when the substrate is used in the magnetic disk, the flying characteristics of the magnetic head can be reliably stabilized by uniformizing air flow in the vicinity of the outer circumferential edge portion on the front side and the back side of the glass substrate.

[0129] In the above-described present embodiment, the case where the magnetic disk device has a configuration in which one or two information recording media are provided has been described as an example, but the present invention is not limited to this case, and the magnetic disk device may have a configuration in which three or more information recording media are provided.

[0130] Although an embodiment and working examples of the present invention have been described above, the disclosed embodiment and examples are exemplary in all respects and in no way limiting. The scope of the present invention is defined by the scope of the appended claims, and all changes that fall within the same essential spirit as the scope of the claims are included therein.

[DescriptionsofReferenceNumerals]

5	[0131] 1G	Glass substrate
	10	Information recording medium
	11	Central hole
	12	Outer circumferential edge surface
	13	Inner circumferential edge surface
	14,15	Main surfaces
	14a,15a	Flat portions
	14b,15b	Inclined portions
	14c,15c	Chamfered portions
	16,17	Magnetic thin film layers
10	20	Actuator
	21	Head slider
	22	Suspension
	23	Arm
	24	Vertical shaft
	25	Voice coil
	26	Voice coil motor
15	27	Clamping member
	28	Fixing screw
	29	Spindle motor

	30	Housing
	100	Magnetic disk device
	200	Double-side polishing device
	210	Upper surface plate
5	211	Upper polishing pad
	211a	Inclined surfaces
	212	Upper polishing surface
	221	Lower polishing pad
	221b	Inclined surfaces
10	230	Sun gear
	232	Tooth surface
	240	Internal gear
	242	Tooth surface
	250	Carrier
15	251	Main body portion
	252	Engaging teeth
	253	Inner circumferential surface
	260	Ring member

Claims

1. A glass substrate for an information recording medium, comprising:
main surfaces that are respectively located on a front side and a back
side of the glass substrate for an information recording medium; and
5 an outer circumferential edge surface that is located in an outer
circumferential edge portion of the glass substrate for an information
recording medium, wherein
when a radius of the glass substrate for an information recording
medium from a center of the glass substrate for an information recording
10 medium to the outer circumferential edge surface is R , and on both the
front side and the back side, points on the main surfaces that are located
 $0.71R$ apart from the center along a diameter direction are first reference
points, points on the main surfaces that are located $0.83R$ apart from the
center along the diameter direction are second reference points, linear
15 lines connecting the first reference points and the second reference
points are reference lines, points on the reference lines that are located
 $0.99R$ apart from the center are reference positions, and distances from
points located on the main surfaces that coincide with the reference
positions as viewed in a thickness direction of the glass substrate for an

information recording medium, to the reference positions are deviation amounts,

the average value of the distribution of the deviation amounts in the circumferential direction is 150 nm or less on both the front side and the

5 back side,

on both the front side and the back side, differences between maximum values and minimum values of distributions of the deviation amounts in the circumferential direction at radius positions located $0.99R$ apart from the center are 40 nm or less, and

10 a difference between an average value of the distribution of the deviation amounts in the circumferential direction on the front side and an average value of the distribution of the deviation amounts in the circumferential direction on the back side is 10 nm or less.

2. The glass substrate for an information recording medium according to claim 1, wherein

15

a thickness of the glass substrate for an information recording medium is 0.65 mm or less.

3. An information recording medium at least having a magnetic layer on the main surfaces of the glass substrate for an information recording medium according to claim 1 or 2.
4. A magnetic disk device, in which a plurality of information recording
5 media according to claim 3 are provided.
5. A magnetic disk device, in which one or more information recording media according to claim 3 are rotated at a rotation rate of 7200 rpm or more.