

DESCRIPTION

[Title of Invention]

METHOD FOR MANUFACTURING MAGNETIC-DISK SUBSTRATE

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[Technical Field]

[0001] The present invention relates to a method for manufacturing a magnetic-disk substrate (that is, a substrate for a magnetic disk), and specifically to a method for manufacturing a magnetic-disk substrate including processing for polishing an edge surface of a substrate.

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[Background Art]

[0002] Nowadays, in order to record data, hard disk drives are incorporated in personal computers, laptop personal computers, DVD (digital versatile disc) recording apparatuses, and the like. In particular, a magnetic disk obtained by providing a magnetic layer on a nonmagnetic substrate for a magnetic disk is used in a hard disk drive used in a device for which portability is a prerequisite, such as a laptop personal computer. A glass substrate is used as a magnetic-disk substrate, for example.

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[0003] In this magnetic disk, in order to prevent malfunction in reproduction due to a thermal asperity failure occurring in the magnetic disk, or in order to prevent a case in which reproduction is not possible, the surfaces of the magnetic disk need to be extremely smooth and to be finished into surfaces that have no foreign matter and are highly clean.

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[0004] It is conceivable that the reason why foreign matter attaches to the surfaces of a magnetic-disk glass substrate is not only because of the surface shape of the main surfaces of a glass substrate but also because of the surface shape of the edge surfaces of the glass substrate. That is, if the surface shape of an edge surface of the magnetic-disk substrate is not smooth, the edge surface scratches a wall surface of a resin case, and minute particles of the resin or glass are generated due to this scratching. Such minute particles and

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minute particles in the atmosphere are then captured by and accumulate on the edge surface of the magnetic-disk glass substrate. The minute particles that have accumulated on the edge surface of the magnetic-disk glass substrate serve as a dust generation source in the later steps or after the glass substrate is mounted in a hard disk drive, and cause attachment of foreign matter to the surfaces of the disk substrate.

[0005] Usually, the edge surface of a magnetic-disk glass substrate is polished using a polishing brush and a polishing slurry. However, in this polishing, the polishing force is small and the processing rate is slow, and thus it has been difficult to manufacture multiple magnetic-disk glass substrates in a short time. On the other hand, a method for polishing a magnetic-disk glass substrate by applying a magnetic field to a magnetic slurry containing magnetic particles and polishing abrasive particles is also known (Patent Literature 1).

Specifically, in the method for performing polishing by applying a magnetic field to a magnetic slurry, in a step of polishing an inner circumferential edge surface of a circular hole at the central portion of a magnetic-disk glass substrate, which is the raw material for a magnetic-disk glass substrate, the magnetic field is formed on the inner circumferential side of the circular hole, the magnetic field is caused to hold the magnetic slurry in this circular hole, the polishing agent is moved relative to the edge surface on the inner circumferential side of the circular hole by moving the magnetic field relative to the edge surface on the inner circumferential side of the circular hole, and thereby, the edge surface on the inner circumferential side of the circular hole is polished with a magnetic polishing method.

More specifically, because a pair of magnets are provided on the outside of the magnetic-disk glass substrate and on the inner circumferential side of the circular hole, magnetic field lines formed by the pair of magnets extend in the radial direction of the magnetic-disk glass substrate.

[Citation List]

[Patent Literature]

[0006] [PLT1]: JP 2005-50501A

[Summary of Invention]

[Technical Problem]

[0007] However, in magnetic polishing for a magnetic-disk glass substrate
5 above, in addition to the inner circumferential side of the circular hole of the
magnetic-disk glass substrate, a magnet is provided on the outer
circumferential side, and thus a distance between the inner side edge surface to
be polished and the magnet provided on the outer circumferential side
increases, as a result of which the magnetic slurry cannot be sufficiently held.
10 As a result, there have been problems in that the polishing rate is small and the
surface roughness of the inner side edge surface to be polished is not efficiently
reduced.

Also, the edge surface of the magnetic-disk glass substrate includes a
side wall surface of the glass substrate and chamfered surfaces provided
15 between this side wall surface and main surfaces. On this edge surface, if the
above-described magnetic polishing method was used, there was a difference in
the polishing rates for the side wall surface and the chamfered surfaces of the
glass substrate, and the polishing machining allowance amounts, which were
desired, were not achieved at the same time. Therefore, in some cases, even if
20 the polishing of the side wall surface ends, the polishing of the chamfered
surfaces has not ended, and the chamfered surfaces have been insufficiently
polished. In this case, when the chamfered surfaces are further polished, the
side wall surface is also polished simultaneously, and thus, a target shape of
the edge surface cannot be achieved due to polishing changing the size of the
25 side wall surface. Furthermore, because extra polishing is performed on the
side wall surface that has undergone polishing, extra magnetic slurry is used,
and thus there is a lot of waste in manufacturing. Such a problem also
similarly arises in the polishing of an edge surface of not only a glass substrate
but also a nonmagnetic substrate such as an aluminum alloy substrate.

30 [0008] In view of this, an object of the present invention is to provide a method

for manufacturing a magnetic-disk substrate according to which it is possible to adjust the ratio of polishing rates for a side wall surface and a chamfered surface of a magnetic-disk substrate in processing for polishing an edge surface of the substrate such as a glass substrate.

5 [Solution to Problem]

[0009] An aspect of the present invention is a method for manufacturing a magnetic-disk substrate including edge surface polishing processing for polishing an edge surface that includes a side wall surface of a disk-shaped substrate and a chamfered surface provided between the side wall surface and
 10 a main surface of the substrate simultaneously, using magnetic functional fluid containing polishing abrasive particles and magnetic particles. In this manufacturing method, before the edge surface polishing processing, a relationship between a ratio of a particle size of polishing abrasive particles with respect to a particle size of magnetic particles, and a ratio of a polishing
 15 rate for a chamfered surface of a substrate with respect to a polishing rate for a side wall surface of the substrate when an edge surface of the substrate is polished using magnetic functional fluid containing the magnetic particles and the polishing abrasive particles that have the ratio of the particle sizes is acquired in advance, the ratio of the particle sizes is set based on a target ratio
 20 of a polishing rate for the side wall surface and a polishing rate for the chamfered surface of the substrate that is to be subjected to the edge surface polishing processing, and magnetic functional fluid containing magnetic particles and polishing abrasive particles that achieve the set ratio of the particle sizes is produced,

25 in the edge surface polishing processing,

a mass of the magnetic functional fluid is formed by a magnetism generation means, and

the edge surface of the substrate that is subjected to the edge surface polishing processing is polished by moving the edge surface of the substrate

relative to the mass in a state in which the edge surface is in contact with the mass.

[0010] It is preferable that in the edge surface polishing processing, the magnetism generation means is used to form magnetic field lines that advance in a thickness direction of the substrate that is to be subjected to the edge surface polishing processing, the produced magnetic functional fluid is disposed on the magnetic field lines to cause the magnetic field lines to hold the magnetic functional fluid along the magnetic field lines, the edge surface of the substrate that is to be subjected to the edge surface polishing processing is moved relative to the magnetic functional fluid in a state in which the edge surface is in contact with the magnetic functional fluid held by the magnetic field lines, and thereby, the edge surface of the substrate is polished.

It is preferable that the ratio of the particle sizes in the magnetic functional fluid used in the edge surface polishing processing is 0.6 or less.

[0011] Also, another aspect of the present invention is a method for manufacturing a magnetic-disk substrate including edge surface polishing processing for polishing an edge surface that includes a side wall surface of a disk-shaped substrate and a chamfered surface provided between the side wall surface and a main surface of the substrate simultaneously, using magnetic functional fluid containing polishing abrasive particles and magnetic particles. In the edge surface polishing processing of the manufacturing method,

a mass of the magnetic functional fluid is formed by a magnetism generation means, and

the edge surface of the substrate that is to be subjected to the edge surface polishing processing is moved relative to the mass in a state in which the edge surface is in contact with the mass. At this time, a ratio of a particle size of the polishing abrasive particles with respect to a particle size of the magnetic particles in the magnetic functional fluid used in the edge surface polishing processing is 0.6 or less.

[0012] In the edge surface polishing processing, it is preferable that the magnetism generation means is used to form magnetic field lines that advance in a thickness direction of a substrate that is to be subjected to the edge surface polishing processing, the produced magnetic functional fluid is disposed on the magnetic field lines to cause the magnetic field lines to hold the magnetic functional fluid along the magnetic field lines, the edge surface of the substrate that is to be subjected to the edge surface polishing processing is moved relative to the magnetic functional fluid held by the magnetic field lines in a state in which the edge surface is in contact with the magnetic functional fluid, and thereby, the edge surface of the substrate is polished.

Note that it is preferable that the ratio of the particle sizes in the magnetic functional fluid used in the edge surface polishing processing is 0.1 or more.

[0013] It is preferable that an average particle size d50 of the polishing abrasive particles is in a range of 0.1 to 10 μm .

[0014] It is preferable that an average particle size d50 of the magnetic particles is in a range of 0.5 to 20 μm .

[0015] It is preferable that a relative speed of a circumferential speed of the substrate relative to the magnetic functional fluid at a position where the substrate is in contact with the magnetic functional fluid is 50 to 500 m/minute.

[ADVANTAGEOUS EFFECTS OF INVENTION]

[0016] According to the above-described method for manufacturing a magnetic-disk substrate, it is possible to adjust a ratio of a polishing rate for a side wall surface and a polishing rate for a chamfered surface of a substrate such as a magnetic-disk glass substrate.

[Brief Description of Drawings]

[0017] FIGS. 1(a) to 1(c) are diagrams illustrating a polishing apparatus used in edge surface polishing processing of this embodiment.

FIG. 2 is a diagram illustrating edge surface polishing processing of this embodiment.

FIG. 3 is a diagram showing an example of the relationship between a ratio of a particle size of polishing abrasive particles with respect to a particle size of magnetic particles used in the edge surface polishing processing of this embodiment and a ratio of a polishing rate for a chamfered surface with respect to a polishing rate for a side wall surface.

FIG. 4 is a diagram illustrating a polishing machining allowance amount measured to obtain a ratio of polishing rates used in this embodiment.

FIG. 5 is a diagram showing an example of indices for the polishing rate for the side wall surface in this embodiment.

FIG. 6 is a diagram illustrating an example in which in the edge surface polishing processing in this embodiment, edge surface polishing processing is simultaneously performed on an inner circumferential side edge surface and an outer circumferential side edge surface of a glass substrate.

[Description of Embodiments]

[0018] Hereinafter, a method for manufacturing a magnetic-disk glass substrate according to the present invention will be described in detail.

As a result of checking polishing machining allowance amounts for a side wall surface and chamfered surfaces by variously changing polishing conditions in edge surface polishing processing for simultaneously polishing the side wall surface and the chamfered surfaces using magnetic functional fluid containing polishing abrasive particles and magnetic particles in a space in which magnetic field lines were generated, the inventor of this invention found that the polishing machining allowance amounts changed in accordance with the ratio of the particle size of the polishing abrasive particles and the particle size of the magnetic particles, and the inventor achieved the following technique using this finding.

[0019] Magnetic disk and magnetic-disk glass substrate

A central portion of the disk shape of a magnetic disk of the present embodiment is concentrically hollowed out so that the magnetic disk has a ring shape, and the magnetic disk rotates about the center of the ring. This

magnetic disk includes at least a nonmagnetic substrate for a magnetic disk and a magnetic layer. Although a glass substrate is used as a nonmagnetic substrate in the present embodiment, an aluminum alloy substrate may be also used. Note that in addition to the magnetic layer, an adherent layer, a soft magnetic layer, a nonmagnetic base layer, a vertical magnetic recording layer, a protecting layer, a lubricant layer, and the like are formed on the glass substrate. A Cr alloy or the like is used as the adherent layer, for example. The adherent layer functions as a layer for affixing the glass substrate. A CoTaZr alloy or the like is used as the soft magnetic layer, for example. A granular nonmagnetic layer or the like is used as the nonmagnetic base layer, for example. A granular magnetic layer or the like is used as the vertical magnetic recording layer, for example. A material made of hydrogen carbon is used as the protecting layer. A fluorine-based resin or the like is used as the lubricant layer, for example.

A central portion of the disk shape of a glass substrate used as a magnetic disk is also concentrically hollowed out so that the glass substrate has a ring shape. The inner circumferential side edge surface and the outer circumferential side edge surface of the glass substrate includes side wall surfaces and chamfered surfaces. The side wall surface is a surface extending vertically toward the main surfaces of the glass substrate in cross-sectional view. In the cross-sectional view, two chamfered surfaces are provided between the side wall surface and the main surfaces, and are surfaces that are inclined with respect to the side wall surface and extend linearly or arcuately to the main surfaces. Note that the chamfered surfaces may include a combination of linear and arcuate shapes in the cross-sectional view.

There is no particular limitation on the diameter of the magnetic-disk glass substrate, and the glass substrate can be used as a substrate having a nominal size of 1.8 to 3.5 inches, for example. There is also no particular limitation on the substrate thickness, and it may be 0.3 to 3 mm, for example.

[0020] Aluminosilicate glass, soda-lime glass, borosilicate glass, and the like can be used as a material for the magnetic-disk glass substrate in the present embodiment. In particular, aluminosilicate glass can be suitably used in light of the fact that chemical strengthening can be carried out, and a magnetic-disk glass substrate that is excellent in flatness of main surfaces and substrate strength can be produced.

[0021] Although there is no limitation on the composition of the magnetic-disk glass substrate of the present embodiment, the glass substrate of the present embodiment is preferably aluminosilicate glass having a composition including, in terms of oxide amount in mol%, SiO_2 in an amount of 50 to 75%, Al_2O_3 in an amount of more than 0% to 15% or less, at least one component selected from Li_2O , Na_2O , and K_2O in a total amount of 12 to 35%, at least one component selected from MgO , CaO , SrO , BaO , and ZnO in a total amount of 0 to 20%, and at least one component selected from ZrO_2 , TiO_2 , La_2O_3 , Y_2O_3 , Ta_2O_5 , Nb_2O_5 , and HfO_2 in a total amount of 0 to 10%.

As disclosed in Patent Literature 2009-99239A, for example, the glass substrate of the present embodiment may be amorphous aluminosilicate glass having a composition including, in mass%, SiO_2 in an amount of 57 to 75%, Al_2O_3 in an amount of 5 to 20% (it should be noted that the total amount of SiO_2 and Al_2O_3 is 74% or more), ZrO_2 , HfO_2 , Nb_2O_5 , Ta_2O_5 , La_2O_3 , Y_2O_3 , and TiO_2 in a total amount of more than 0% to 6% or less, Li_2O in an amount of more than 1% to 9% or less, Na_2O in an amount of 5 to 18% (it should be noted that a mass ratio $\text{Li}_2\text{O}/\text{Na}_2\text{O}$ is 0.5 or less), K_2O in an amount of 0 to 6%, MgO in an amount of 0 to 4%, CaO in an amount of more than 0% to 5% or less (it should be noted that the total amount of MgO and CaO is 5% or less and the content of CaO is larger than that of MgO), and $\text{SrO}+\text{BaO}$ in an amount of 0 to 3%, for example.

[0022] Edge surface polishing processing

FIGS. 1(a) to 1(c) are diagrams illustrating an apparatus used in edge surface polishing processing, which is one type of processing of the method for manufacturing a glass substrate of the present embodiment, and FIG. 2 is a

diagram illustrating the edge surface polishing processing of the present embodiment. An example in FIG. 2 depicts the polishing of the inner circumferential side edge surface of the glass substrate. Regarding edge surface polishing, a similar method can be applied to the polishing of the outer circumferential side edge surface of the glass substrate.

In the edge surface polishing processing, an edge surface of a substrate is polished by forming a mass of magnetic functional fluid, which will be described later, by a magnetism generation means, and moving the edge surface of the substrate that is to be subjected to the edge surface polishing processing relative to the mass in a state in which the edge surface is in contact with the mass.

At this time, the magnetism generation means is used to form magnetic field lines that advance in the thickness direction of the substrate that is to be subjected to the edge surface polishing processing, the produced magnetic functional fluid is disposed on the magnetic field lines to cause the magnetic field lines to hold the magnetic functional fluid along the magnetic field lines, the edge surface of the substrate that is to be subjected to the edge surface polishing processing is moved relative to the magnetic functional fluid in a state in which the edge surface is in contact with the magnetic functional fluid held by the magnetic field lines, and thereby, the edge surface of the substrate is polished.

To give a description of an overview of an apparatus 10 that performs edge surface polishing, as shown in FIG. 1(a), the apparatus 10 includes a pair of magnets 12 and 14, which are permanent magnets, and a spacer 16, and has a rotary shape extending in one direction. The spacer 16 is provided between the magnet 12 and the magnet 14. A glass substrate 11 on which edge surface polishing is performed is held by a holder (not shown). The apparatus 10 is allowed to pass through a circular hole of the glass substrate 11 held by the holder, a mass 20 (see FIGS. 1(c) and 2) of magnetic functional fluid containing magnetic particles and polishing abrasive particles, which will be described

later, and the inner circumferential side edge surface of the glass substrate 11 are brought into contact with each other. The magnetic functional fluid becomes the annular mass 20 around the apparatus 10. At this time, the glass substrate 11 is disposed such that the central axis of the glass substrate 11 and the central axes of the magnets 12 and 14 and the spacer 16 of the apparatus 10 are oriented in the same direction. The apparatus 10 and the holders (not shown) for holding the glass substrates 11 are mechanically connected to a driving motor (not shown). The rotary-shaped apparatus 10 and the holder for the glass substrate 11 rotate about the central axes thereof and move the edge surface of the glass substrate 11 and the mass 20 relative to each other. As shown in FIG. 2, the edge surface of the glass substrate 11 and the mass 20 may have the same rotation direction or opposite rotation directions. Accordingly, the inner circumferential side edge surface of the glass substrate 11 can be polished. Note that an external member may be provided so as to cover the magnets 12 and 14 and the spacer 16. Although the central axis of the glass substrate 11 and the central axis of the apparatus 10 are offset in the example shown in FIG. 2, the central axis of the glass substrate 11 may coincide with the central axis of the apparatus 10.

[0023] When the inner circumferential side edge surface of the glass substrate 11 is polished, the mass 20 of the magnetic functional fluid rotates due to the rotation of the apparatus 10 about the central axis, whereas the glass substrate 11 also rotates about the central axis. At this time, in order to efficiently polish the edge surface, the relative speed of the circumferential speed of the glass substrate 11 relative to the mass 20 of the magnetic slurry at a position where the glass substrate 11 is in contact with the mass 20 of the magnetic functional fluid is preferably 50 to 500 m/minute, and more preferably 200 to 400 m/minute. Note that the glass substrate 11 and the mass 20 can be rotated by bringing the entire circumference of the inner circumferential side edge surface of the glass substrate 11 and the entire circumference of the mass 20 into contact with each other. Because the mass 20 of the magnetic

functional fluid is formed into an annular shape, the inner circumferential side edge surface, which is an inner wall surface of the circular through hole of the glass substrate 11, can be polished so as to not deform the shape of the circular hole. In this case, it is preferable to set the rotation rate of the glass substrate 11 to 500 to 4000 rpm, for example, and to set the rotation rate of the mass 20 to 50 to 300 rpm, for example. Note that, as described later, in the case where the outer circumferential side edge surface of the glass substrate 11 is polished, it is preferable to set the rotation rate of the glass substrate 11 to 500 to 4000 rpm, for example, and to set the rotation rate of the mass 20 to 50 to 300 rpm, for example. The edge surface can be efficiently polished due to such rotation rates.

[0024] It is preferable that the rotation direction of the glass substrate 11 and the rotation direction of the mass 20 are opposite to each other at a position where the glass substrate 11 is in contact with the mass 20 in light of the fact that the edge surface polishing processing is efficiently performed. On the other hand, it is preferable that the rotation direction of the glass substrate 11 and the rotation direction of the mass 20 are the same direction at a position where the glass substrate 11 is in contact with the mass 20 in light of the fact that surface unevenness on the edge surface that has undergone the edge surface polishing processing is reduced.

Note that if the edge surface of the glass substrate 11 and the mass 20 can be moved relative to each other, the glass substrate 11 may be rotated without rotating the mass 20.

[0025] To give a more specific description of edge surface polishing, the magnet 12 and the magnet 14 come close to each other, function as the magnetism generation means, and form magnetic field lines 19 as shown in FIG. 1(b). A portion of these magnetic field lines 19 advance linearly from the center of the magnets 12 and 14 and advance in the thickness direction of the glass substrate 11. A portion of these magnetic field lines 19 protrude outwardly from the center of the magnets 12 and 14 and advance in the thickness

direction of the glass substrate 11. In the example shown in FIG. 1(b), the pair of magnets disposed in a state in which the N-pole surface and the S-pole surface are disposed apart from each other and facing each other in the thickness direction of the glass substrate 11 is used as a magnetism generation means. "Surfaces facing each other" refers to a surface and a surface facing each other, that is, surfaces being face-to-face with each other. In order that a clearance between the N-pole edge surface of the magnet 12 and the S-pole edge surface of the magnet 14 is set to a predetermined distance, the spacer 16 made of a nonmagnetic material is provided between the magnets 12 and 14. The reason why the clearance between the N-pole edge surface of the magnet 12 and the S-pole edge surface of the magnet 14 is set to a predetermined distance is so that the mass 20 of the magnetic slurry as shown in FIG. 1(c) is formed along the outer circumference of the apparatus 10 by, as shown in FIG. 1(b), allowing a portion of the magnetic field lines 19 to advance downward in FIG. 1(b) in a recessed groove between the magnet 12 and the magnet 14, and allowing a portion of the magnetic field lines 19 to protrude outwardly from the magnet 12 and the magnet 14. Because the mass 20 is a portion that comes into contact with the edge surface of the glass substrate 11 and moves relative to this edge surface, in terms of securing the rigidity of the mass 20, the magnetic force needs to be strong to some extent. Therefore, the clearance between the N-pole edge surface of the magnet 12 and the S-pole edge surface of the magnet 14 is preferably short, but if the clearance is excessively short, the mass 20 cannot be sufficiently formed. Thus, the clearance between the N-pole edge surface of the magnet 12 and the S-pole edge surface of the magnet 14 is defined in a predetermined range.

[0026] In the polishing of the edge surface of a glass substrate of the present embodiment, it is preferable that the edge surface of the glass substrate 11 is polished by being pressed into an inner portion of the mass 20 in a direction orthogonal to the magnetic field lines in light of the fact that the polishing rate is increased. Because the edge surface of the glass substrate 11 receives a

large resistance from the mass 20 by being pressed in the direction orthogonal to the magnetic field lines, polishing is promoted.

The edge surface of the glass substrate 11 of the present embodiment is pressed into the inner portion of the mass 20 so as to come into contact with a portion held by magnetic field lines connecting the N-pole of the magnet 12 and the S-pole of the magnet 14 in the inner portion of the mass 20 of the magnetic slurry, or in other words, the magnetic field lines extending from the N-pole or the S-pole and ending at the S-pole or the N-pole. A portion of the magnetic slurry held along the magnetic field lines connecting the N-pole of the magnet 12 and the S-pole of the magnet 14 has higher rigidity than a portion in which the magnetic field lines do not end at the magnet pole, and realizes a high polishing rate. On the other hand, because the main surfaces of the glass substrate 11 come into contact with a portion of the mass 20 that has a low rigidity and is held by magnetic field lines whose majority is blocked by the glass substrate 11 and do not reach the pole of the magnet, even if the mass 20 and the main surfaces of the glass substrate 11 come into contact with each other, the main surfaces are unlikely to be polished.

The mass 20 may be formed in a recessed groove in which the outer circumferential surface of the spacer 16 serves as a bottom surface of the groove and the edge surfaces of the magnet 12 and the magnet 14 serve as the side wall surfaces, and the edge surface of the glass substrate may be pressed into the mass 20 in this groove, or as shown in FIG. 1(c), the mass 20 may protrude from a recessed portion between the magnet 12 and the magnet 14, and the edge surface of the glass substrate may be pressed into this protrusion.

[0027] As described above, although the glass substrate 11 is pushed into the mass 20 such that the side wall surface and the chamfered surfaces are polished simultaneously, a portion of the main surfaces of the glass substrate that comes into contact with the mass 20 is substantially not polished.

[0028] Note that although permanent magnets are used as a magnetism generation means in the example shown in FIGS. 1(a) to 1(c) and FIG. 2,

electromagnets may be used. Also, in order to ensure that the clearance between the N-pole side edge surface of the magnet 12 and the S-pole edge surface of the magnet 14 is a certain distance, the spacer 16 is used. However, it is also possible to ensure that the clearance between the N-pole edge surface of the magnet 12 and the S-pole side edge surface of the magnet 14 is a certain distance by fixing the magnets 12 and 14 to an external member (not shown) without using the spacer 16.

[0029] Magnetorheological fluid that contains nonpolar oil containing magnetic particles made of Fe in an amount of 3 to 5 g/cm³, and surfactant, for example, is used as magnetic functional fluid used in edge surface polishing. In this specification, the magnetic functional fluid is formed by including polishing abrasive particles in this magnetorheological fluid. The nonpolar oil or polar oil has a viscosity of 100 to 1000 (mPa • sec) at room temperature (20°C), for example. As described later, the average particle size d50 (diameter) of magnetic particles is preferably 2.0 to 7.0 μm in light of the fact that the ratio of the polishing rate for the chamfered surface with respect to the polishing rate for the side wall surface is suitably adjusted. The average particle size d50 is a median value in the particle size distribution.

When the magnetic functional fluid is formed as a mass on the magnetic field lines, the mass 20 formed by the magnetic functional fluid includes polishing abrasive particles as well as magnetic particles. Because the polishing abrasive particles in the magnetic functional fluid are pushed into a portion having a low magnetic force gradient due to a magnetic levitation effect, the polishing abrasive particles are unevenly present in the vicinity of an edge surface of the glass substrate that is to be polished. Moreover, because the magnetic functional fluid forms a relatively highly elastic mass due to the magnetic field lines, polishing can be efficiently performed by the edge surface of the glass substrate being pressed against the mass 20. That is, the polishing rate can be increased and polishing can be efficiently performed.

[0030] Known polishing abrasive particles for a glass substrate, such as cerium oxide, colloidal silica, zirconia oxide, alumina abrasive particles, diamond abrasive particles, silica abrasive particles, or SiC abrasive particles, may be used as the polishing abrasive particles included in the magnetic functional fluid. The particle size of the polishing abrasive particles is preferably 0.4 to 3.0 μm , for example, in light of the fact that the ratio of the polishing rate for the chamfered surface with respect to the polishing rate for the side wall surface is suitably adjusted and the high-quality surface is efficiently obtained. Use of polishing abrasive particles in this range makes it possible to favorably polish the inner circumferential side edge surface of the glass substrate. The magnetic functional fluid contains the polishing abrasive particles in an amount of 3 to 15 vol%, for example. Note that because the polishing rate is a value obtained by dividing the polishing machining allowance amount by a polishing time, if it takes the same polishing time, the ratio of the polishing rates and the ratio of the polishing machining allowance amounts take the same value, and are synonymous with each other. Therefore, in this case, the adjustment of the ratio of the polishing rates indicates the adjustment of the ratio of the polishing machining allowance amounts.

[0031] The viscosity of the magnetic functional fluid using the magnetorheological fluid is preferably 1000 to 2000 ($\text{mPa}\cdot\text{sec}$) at room temperature (20°C) due to the adjustment of the concentration of the magnetorheological fluid in light of the fact that the mass 20 is formed and the edge surface polishing is efficiently performed. If the viscosity is low (the concentration of the magnetorheological fluid is low), the mass 20 is unlikely to form, and it is difficult to perform polishing by relative movement in a state in which the mass 20 is pressed against the edge surface of the glass substrate 11. On the other hand, if the viscosity of the magnetic functional fluid is excessively high, the mass 20 will have a shape recessed along the shape of an edge portion of the glass substrate 11 during polishing, will be unlikely to be restored to its original state from this shape, and the shape of the glass

substrate 11 will significantly remain on the mass 20. Thus, it will be difficult to form a state in which the mass 20 is evenly pressed against the edge surface. Also, the magnetic flux density in the magnetism generation means is preferably 0.3 to 2 (tesla) in light of the fact that the mass 20 is formed and edge surface polishing is efficiently performed. Also, the yield stress of the magnetorheological fluid is preferably 30 kPa or more and more preferably 30 to 60 kPa in a state in which a magnetic field having a magnetic flux density of 0.4 (tesla) is applied.

[0032] In the present embodiment, before such edge surface polishing processing, a relationship between a ratio of a particle size of the polishing abrasive particles with respect to a particle size of the magnetic particles and a ratio of a polishing rate for a chamfered surface of the glass substrate 11 with respect to a polishing rate for a side wall surface of the glass substrate 11 when edge surface polishing is performed using a magnetic slurry containing magnetic particles and polishing abrasive particles that have the ratio of the particle sizes is acquired in advance. Furthermore, the above-described ratio of the particle sizes is set based on a target ratio of a polishing rate for the side wall surface of the glass substrate 11 with respect to a polishing rate for the chamfered surface, and magnetic functional fluid containing magnetic particles and polishing abrasive particles that achieve the set ratio of the particle sizes is produced. The reason why such magnetic functional fluid is produced is that it has been found that there is a correlational relationship between the ratio of the particle size of polishing abrasive particles with respect to the particle size of magnetic particles and the ratio of a polishing rate for the chamfered surface with respect to a polishing rate for the side wall surface, and as described later, the smaller the above-described particle size ratio is, the higher the above-described polishing rate is.

[0033] FIG. 3 is a diagram showing an example of a relationship between the ratio of the particle size of the polishing abrasive particles with respect to the particle size of the magnetic particles and the ratio of the polishing rate for the

chamfered surface with respect to the polishing rate for the side wall surface. In the example shown in FIG. 3, magnetic particles made of Fe and having an average particle size d50 (diameter) of 2 μm , 4 μm , and 7 μm were used, and zirconia abrasive particles were used as the polishing abrasive particles. At this time, the above-described particle size ratio was variously changed by variously changing the average particle size d50 (diameter) of the polishing abrasive particles.

[0034] Note that in order to obtain the polishing rate for the side wall surface and the polishing rate for the chamfered surface, as shown in FIG. 4, the cross-sectional shapes of a side wall surface 11a and a chamfered surface 11b of the edge surface were measured with an outline shape measurement device before and after the edge surface polishing processing. The ratio of polishing rates was obtained by obtaining polishing machining allowance amounts P_1 and P_2 in a central portion in the thickness direction of the side wall surface 11a and the central portion in the direction of the chamfered surface 11b from the measured cross-sectional shapes. Note that FIG. 4 is a diagram illustrating the polishing machining allowance amount.

[0035] As is understood from FIG. 3, in the cases where the average particle size d50 (diameter) of the magnetic particles is 2 μm , 4 μm , and 7 μm , correlational relationships that are approximately the same are shown. From this correlational relationship, it is understood that reducing the particle size ratio (reducing the particle size of the polishing abrasive particles, or increasing the particle size of the magnetic particles) makes it possible to improve the ratio of the polishing rate for the chamfered surface 11b with respect to the polishing rate for the side wall surface 11a. Thus, if the chamfered surface 11b is polished insufficiently, the polishing rate for the side wall surface 11a and the polishing rate for the chamfered surface 11b can be made substantially equal to each other by reducing the average particle size d50 (diameter) of the polishing abrasive particles or increasing the particle size

of the magnetic particles, and the chamfered surface 11b can be polished sufficiently.

[0036] In this manner, the ratio of the polishing rates can be defined using the ratio of the average particle size d50 (diameter) of the polishing abrasive particles with respect to the average particle size d50 (diameter) of the magnetic particles. Accordingly, the ratio of the polishing rate for the side wall surface 11a and the polishing rate for the chamfered surface 11b can be adjusted by adjusting the particle size ratio through changing the average particle size d50 (diameter) of either the magnetic particles or the polishing abrasive particles.

Such a correlational relationship is confirmed in a case where the average particle size d50 (diameter) of the polishing abrasive particles is in a range of 0.1 to 10 μm . Also, such a correlational relationship is confirmed in a case where the average particle size d50 (diameter) of the magnetic particles is in a range of 0.5 to 20 μm . In these range, the average particle size d50 (diameter) of the polishing abrasive particles is preferably 0.4 to 3.0 μm in light of the fact that a target polishing rate is more precisely achieved and a high-quality surface is efficiently obtained, and the average particle size d50 (diameter) of the magnetic particles is preferably 2.0 to 7.0 μm in light of the fact that a target polishing rate is more precisely achieved and a high-quality surface is efficiently obtained.

[0037] Although the mechanism of the occurrence of such a relationship is not clear, it is inferred as follows. That is, as shown in FIG. 1(c), when the magnetic functional fluid is in the state of the mass 20, the magnetic particles in the magnetic functional fluid form lines of the magnetic particles arranged along the magnetic field lines, and the mass 20 has a high rigidity. At this time, the polishing abrasive particles disperse around the magnetic particles. In this state, when the edge surface of the glass substrate 11 enters the inner portion of the mass 20, the mass 20 undergoes elastic deformation and its shape changes. On the other hand, the edge surface of the glass substrate 11 can be

pressed against the mass 20 due to the mass 20 having a high rigidity, and the edge surface of the glass substrate 11 slides relative to the mass 20 with this pressing force at a relative speed between the mass 20 and the edge surface of the glass substrate 11, and the edge surface can be polished. At this time, the
5 above-described lines are easily disconnected because the larger the particle size of the polishing abrasive particles is, the greater the force with which the lines of the magnetic particles are cut into is due to the shape deformation of the mass 20.

Here, since the edge surface of the glass substrate 11 enters the mass
10 20, the lines of the magnetic particles in the mass 20 deform so as to extend along the shape of the edge surface constituted by the side wall surface 11a and the chamfered surfaces 11b and recess in a valley shape, and the mass 20 exhibits resistance toward the edge surface of the glass substrate 11. At this time, a region of the lines of magnetic particles located in the vicinity of the side
15 wall surface 11a in the deformed mass 20 receives a force of the side wall surface 11a from a direction orthogonal to the direction in which the lines of the magnetic particles extend, whereas a region of lines of magnetic particles located in the vicinity of the chamfered surface 11b is located in a portion in which the lines that have deformed in a valley shape are inclined and thus the
20 region extends along a direction in which the glass substrate 11 enters the mass 20. This portion in which lines are inclined receives a force from the glass substrate 11 in a direction in which the glass substrate 11 enters the mass 20. In particular, when polishing abrasive particles having a large particle size cut into the lines in the portion in which the lines located in the
25 vicinity of the chamfered surfaces 11b are inclined, this portion receives a force oriented in the direction in which the glass substrate 11 enters the mass, from the glass substrate 11, and the distance between the magnetic particles on the above-described lines increases. Thus, the above-described lines are easily disconnected. Therefore, the magnetic slurry in this region cannot maintain a
30 high rigidity, and a force that the polishing abrasive particles supported by the

lines of the magnetic particles give to the chamfered surface 11b decreases. Thus, the polishing rate for the chamfered surface 11b more easily decreases compared to that for the side wall surface 11a. On the other hand, if the particle size of the polishing abrasive particles is small, the force with which
 5 the polishing abrasive particles cut into the lines of the magnetic particles located in the vicinity of the chamfered surfaces 11b is weak, and therefore the lines are unlikely to be disconnected.

The above description applies in a case where the particle size of the polishing abrasive particles is constant and the particle size of the magnetic
 10 particles changes. Therefore, if the ratio of the particle size of the polishing abrasive particles with respect to the particle size of the magnetic particles is increased, the ratio of the polishing rate for the chamfered surface 11b with respect to the polishing rate for the side wall surface 11a decreases, whereas if the particle size ratio is reduced, the ratio of the polishing rate for the
 15 chamfered surface 11b with respect to the polishing rate for the side wall surface 11a increases, and approaches 1.0.

[0038] Regarding the surface roughnesses of the side wall surface 11a and the chamfered surfaces 11b that have undergone the edge surface polishing processing using such magnetic slurry, the maximum height Rz (JIS B0601:
 20 2001) is preferably 0.15 μm or less. Accordingly, the depths of minute grooves occurring on the side wall surface 11a and the chamfered surfaces 11b decrease, and thus the likelihood that the minute particles will attach thereto decreases. Also, arithmetic average roughnesses Ra (JIS B0601: 2001) of the side wall surface 11a and the chamfered surfaces 11b that have undergone the edge
 25 surface polishing processing are preferably 0.015 μm or less.

Such a surface roughness has a maximum height Rz and an arithmetic average roughness Ra measured in a 50 μm ×50 μm square evaluation region using a laser microscope under the following conditions. At this time, the resolution in the height direction is preferably 1 nm or less. Also, the

observation magnification may be selected as appropriate in a range of about 1000 to 3000-fold in accordance with the size of a measurement surface.

Observation magnification: 3000-fold,

Measurement pitch in height direction (Z axis): 0.01 μm ,

5 Cutoff value λ_s : 0.25 μm , and

Cutoff value λ_c : 80 μm .

[0039] Note that if the particle size ratio is reduced, the ratio of the polishing rate for the chamfered surface 11b with respect to the polishing rate for the side wall surface 11a improves, but the polishing force decreases due to a decrease
10 in the particle size of the polishing abrasive particles, resulting in a decrease in the polishing rate. FIG. 5 is a diagram showing an example of an index for the polishing rate for the side wall surface 11a. In the example shown in FIG. 5, the particle size of an average particle size d50 (diameter) of the polishing abrasive particles was variously changed with the average particle size d50
15 (diameter) of the magnetic particles kept constant at 2 μm . The index for the polishing rate is obtained by standardization using the polishing rates at a particle size ratio of 1.2 as 1.00 (the higher the index is, the higher the polishing rate is). According to FIG. 5, it is understood that the smaller the particle size ratio is, the lower the polishing rate is. Thus, in order to prevent
20 the processing time of the processing for polishing an edge surface of the glass substrate 11 from increasing, the particle size ratio is preferably 0.1 or more, and more preferably 0.2 or more.

[0040] Note that in the process of manufacturing a glass substrate, the side wall surface 11a and the chamfered surfaces 11b are formed by shape
25 processing in which the edge surface of the glass substrate is ground with a grinding grindstone. The surface roughnesses of the side wall surface 11a and the chamfered surfaces 11b formed by this grinding grindstone are often about the same. Thus, the side wall surface 11a and the chamfered surfaces 11b often require polishing machining allowance amounts that are approximately
30 the same in the edge surface polishing processing. Therefore, in this case, in

the edge surface polishing processing, it is preferable that the polishing rate for the side wall surface 11a and the polishing rate for the chamfered surfaces 11b are approximately the same. In this respect, the ratio of the polishing rate for the chamfered surface 11b with respect to the polishing rate for the side wall surface 11a is preferably set to 0.8 or more, and is more preferably set to 0.9 or more. If the ratio of the polishing rates is set to less than 0.8, the polishing rate for the chamfered surfaces 11b decreases excessively compared to the polishing rate for the side wall surface 11a, and if the edge surface polishing processing is ended in accordance with the polishing machining allowance amount for the side wall surface 11a, in some cases, the chamfered surface is polished insufficiently and the surface roughness of the chamfered surface is rougher than a target surface roughness. On the other hand, if the edge surface polishing processing is ended in accordance with the polishing machining allowance amount for the chamfered surface, it takes time for the processing to end, and the productivity decreases. Thus, in order to achieve the above-described preferred polishing rate ratio, it is preferable to define the ratio of the particle size of the polishing abrasive particles with respect to the particle size of the magnetic particles, using the above-described preferred polishing rate ratio and the correlational relationship shown in FIG. 3.

[0041] In order to set the above-described polishing rate ratio to 0.8 or more, the particle size ratio is set to 0.6 or less, based on the correlational relationship shown in FIG. 3. Therefore, in an aspect of the present embodiment, the ratio of the particle size of the polishing abrasive particles with respect to the particle size of the magnetic particles in a magnetic slurry used in the edge surface polishing processing is 0.6 or less. At this time, the above-described particle size ratio is preferably 0.1 or more, and more preferably 0.2 or more in light of the fact that a large decrease in the polishing rate for the side wall surface 11a is avoided. That is, setting the particle size ratio to 0.1 or more and 0.6 or less, or setting it to 0.2 or more and 0.6 or less makes it possible to end the polishing of the side wall surface 11a and the

polishing of the chamfered surfaces 11b at approximately the same time, the polishing time does not extend, and the processing for polishing the edge surface of the glass substrate 11 can be efficiently performed.

[0042] Note that there are cases where the surface roughness of the side wall surface 11a and the surface roughness of the chamfered surface 11b that have undergone the shape processing are different from each other depending on the way in which shape processing was performed on the side wall surface 11a and the chamfered surface 11b. In this case, the polishing machining allowance amount for the side wall surface 11a and the polishing machining allowance amount for the chamfered surfaces 11b are also different from each other. Thus, the ratio of the polishing rates is defined in accordance with different polishing machining allowance amounts, and the particle size ratio can be defined using the correlational relationship shown in FIG. 3. Accordingly, if edge surface polishing is performed with different polishing machining allowance amounts for the side wall surface 11a and the chamfered surfaces 11b, it is possible to cause the time when the polishing of the side wall surface 11a ends and the time when the polishing of the chamfered surfaces 11b ends to coincide by adjusting the ratio of the polishing rates.

[0043] Although the edge surface polishing processing described above is the edge surface polishing processing for polishing the inner circumferential side edge surface of the glass substrate 11, it can be applied to the edge surface polishing processing for polishing the outer circumferential side edge surface of the glass substrate 11.

FIG. 6 is a diagram illustrating an example in which the edge surface polishing processing is performed on the inner circumferential side edge surface and the outer circumferential side edge surface of the glass substrate 11 simultaneously.

In the example shown in FIG. 6, the inner circumferential side edge surface of the glass substrate 11 is polished, and the outer circumferential side edge surface of the glass substrate 11 is polished simultaneously. That is, the

apparatus 10 in which the mass 20 is formed is allowed to pass through a circular through hole provided in the center of the glass substrate 11, and the mass 20 of the magnetic slurry and the inner circumferential side edge surface of the glass substrate 11 are brought into contact with each other. At the same time, a mass 62 of the magnetic slurry is formed on the surface of the outer circumference of a spacer (not shown) between the magnets 60 and 64, similarly to the magnets 12 and 14 and the spacer 16. The positions of the magnets 60 and 64 and the spacer (not shown) are determined so that the mass 62 comes into contact with the glass substrate 11. Similarly to the magnets 12 and 14 and the spacer 16, the magnets 60 and 64 and the spacer (not shown) are mechanically connected to a driving motor (not shown) and are rotatable. Therefore, the inner circumferential side edge surface and the outer circumferential side edge surface of the glass substrate 11 can be polished simultaneously by rotating the apparatus 10 including the magnets 12 and 14 and the spacer 16 and the apparatus including the magnets 60 and 64 and the spacer (not shown) in different directions, and efficient edge surface polishing is realized. Note that in the example shown in FIG. 6, a situation is shown in which the central axis that is a rotation axis of the glass substrate 11 is offset from the central axis that is the rotation axis of the magnets 12 and 14 and the spacer 16 and only a portion of the inner circumferential side edge surface of the glass substrate 11 is in contact with the mass 20 and is polished. Of course, the central axis that is the rotation axis of the glass substrate 11 may coincide with the central axis that is the rotation axis of the magnets 12 and 14 and the spacer 16 and the entire inner circumferential edge surface of the glass substrate 11 may be evenly polished at the same time.

With such edge surface polishing processing, edge surfaces of a plurality of glass substrates can also be polished simultaneously by aligning a plurality of glass substrates in the direction of the central axis of the apparatus including the magnets and the spacer, forming a plurality of masses 20 and 62

on the outer circumference of the apparatus, and allowing the plurality of masses 20 and 62 to abut against different glass substrates.

Although the side wall surface 11a of the present embodiment extends vertically to the main surfaces of the glass substrate in cross-sectional view, the chamfered surfaces 11b are inclined to the side wall surface and extend linearly to the main surfaces in cross-sectional view, the side wall surface 11a and the chamfered surfaces 11b may be formed into an arc shape in cross-sectional view.

Note that although a mode in which processing for polishing an edge surface of one glass substrate is performed has been described in the present embodiment, edge surfaces of stacked substrates of a substrate stacked body obtained by stacking a plurality of substrates through attaching their main surfaces to each other can be polished simultaneously in the edge surface polishing processing. In this case, the substrate stacked body can be formed by attaching the main surfaces of the stacked substrates to each other with an adhesive such as a thermosetting resin, for example. Accordingly, the productivity of substrates increases.

The above-described edge surface polishing processing is performed as one process of a method for manufacturing a glass substrate described below.

[0044] Method for manufacturing glass substrate

Next, a method for manufacturing a magnetic-disk glass substrate according to the present embodiment will be described. First, a glass blank, which serves as a raw material for a plate-shaped magnetic-disk glass substrate having a pair of main surfaces, is produced by press molding (press molding processing). Note that although the glass blank is produced by press molding in the present embodiment, a glass plate may be formed by a known float method, redraw method, or fusion method, and a glass blank having the same shape as that of the above-described glass blank may be cut out from the glass plate. Next, a circular hole is created in a central portion of the produced glass blank, and a ring-shaped (annular) glass substrate is produced (circular

hole formation processing). Next, shape processing is performed on the glass substrate in which the circular hole is formed (shape processing). Accordingly, the glass substrate is produced. Next, edge surface polishing is performed on the glass substrate that was subjected to shape processing (edge surface polishing processing). Grinding is performed on the main surfaces of the glass substrate that was subjected to edge surface polishing (grinding processing). Next, first polishing is performed on the main surfaces of the glass substrate (first polishing processing). Next, chemical strengthening is performed on the glass substrate as needed (chemical strengthening processing). Next, second polishing is performed on the glass substrate (second polishing processing). Thereafter, ultrasonic cleaning is performed on the glass substrate that has undergone the second polishing processing (ultrasonic cleaning processing). A magnetic-disk glass substrate can be obtained through the above-described processing. Hereinafter, each process will be described in detail.

15 [0045] (a) Press molding processing

A glass blank is molded by cutting the tip of molten glass flow with a cutter, sandwiching the mass of the cut molten glass between press molding surfaces of a pair of metal molds, and pressing the mass. After pressing is performed for a predetermined time, the metal molds are opened to remove the glass blank.

[0046] (b) Circular hole formation processing

A disk-shaped glass substrate having a circular hole can also be obtained by forming the circular hole on the glass blank with a drill or the like.

[0047] (c) Shape processing

25 In the shape processing, chamfering processing is performed on an edge portion of the glass substrate that has undergone the circular hole formation processing. Chamfering is performed using a grinding grindstone, or the like. On the edge surface of the glass substrate, a side wall surface of the substrate that extends vertically to the main surfaces of the glass substrate and chamfered surfaces that are provided between this side wall surface and the

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main surfaces and extend inclined to the side wall surface are formed by chamfering.

[0048] (d) Edge surface polishing processing

In the edge surface polishing processing, mirror finishing is performed on the inner side edge surface and the outer circumferential side edge surface of the glass substrate by edge surface polishing processing shown in FIG. 1 using the above-described magnetic functional fluid. At this time, the magnetic functional fluid contains polishing abrasive particles of cerium oxide, zirconium oxide, silicon oxide, diamond, or the like, in addition to the magnetic particles.

Note that the order of the edge surface polishing processing and the grinding processing may be switched.

[0049] (e) Grinding processing

In the grinding processing, grinding processing is performed on the main surfaces of the glass substrate using a double-side grinding apparatus provided with a planetary gear mechanism. Specifically, both main surfaces of the glass substrate are ground while the glass substrate is held in a holding hole provided in a holding member of the double-side grinding apparatus. The double-side grinding apparatus has a pair of upper and lower surface plates (an upper surface plate and a lower surface plate), and the glass substrate is sandwiched between the upper surface plate and the lower surface plate. The glass substrate and the surface plates are moved relative to each other by moving one or both of the upper surface plate and the lower surface plate, and thereby both main surfaces of the glass substrate can be ground.

[0050] (f) First polishing processing

Next, first polishing is performed on the ground main surfaces of the glass substrate. Specifically, both main surfaces of the glass substrate are polished while the glass substrate is held in a holding hole provided in a carrier for polishing of a double-side polishing apparatus. First polishing is for removing scratches and warping or adjusting minute unevenness

(microwaviness, roughness) remaining on the main surfaces that have undergone the grinding processing.

[0051] In the first polishing processing, the glass substrate is polished using a double-side polishing apparatus having a configuration similar to that of the double-side grinding apparatus used in the grinding processing with fixed abrasive particles, while a polishing slurry is provided. In the first polishing processing, a polishing slurry containing loose abrasive particles is used. Cerium oxide abrasive particles, zirconia abrasive particles, or the like, for example, are used as loose abrasive particles used in first polishing. Similarly to the double-side grinding apparatus, in the double-side polishing apparatus, the glass substrate is also sandwiched between the pair of upper and lower surface plates. Tabular polishing pads (resin polisher, for example) having an annular shape overall are attached to the upper surface of the lower surface plate and the bottom surface of the upper surface plate. The glass substrate and the surface plates are moved relative to each other by moving one or both of the upper surface plate and the lower surface plate, and thereby both main surfaces of the glass substrate are polished.

[0052] (g) Chemical strengthening processing

If the glass substrate is to be chemically strengthened, the glass substrate is immersed in a chemical strengthening liquid using a melt in which potassium nitrate and sodium sulfate are mixed, for example, as the chemical strengthening liquid.

[0053] (h) Second polishing (final polishing) processing

Next, second polishing is performed on the glass substrate. The second polishing processing is for mirror-polishing the main surfaces. In second polishing as well, a double-side polishing apparatus having a configuration similar to that of the double-side polishing apparatus used in first polishing is also used. Specifically, both main surfaces of the glass substrate are polished while the outer circumferential side edge surface of the glass substrate is held in a holding hole provided in a carrier for polishing of the double-side polishing

apparatus. The second polishing processing differs from the first polishing processing in that the type and particle size of the loose abrasive particles are different, and the hardness of the resin polishers is different. For example, a polishing liquid containing colloidal silica as the loose abrasive particles is supplied between the polishing pads of the double-side polishing apparatus and the main surfaces of the glass substrate, and the main surfaces of the glass substrate are polished.

Although the chemical strengthening processing is performed in the present embodiment, it is also possible to not perform the chemical strengthening processing as needed. In addition to the first polishing processing and the second polishing processing, other polishing processing may be added, or two main surfaces may be polished in one instance of polishing processing. Also, the order of the above-described processes may be changed as appropriate.

[0054] Working Examples

In order to confirm the effects of the present embodiment, glass substrates were produced with the following method.

Specifically, circular hole formation processing is performed on a disk-shaped glass blank obtained by a pressing method, and a disk-shaped glass substrate having a circular hole in the center portion was obtained. Upper and lower main surfaces of this disk-shaped glass plate were subjected to the grinding processing using a double-side grinding apparatus including a pair of grinding surface plates, and the substrate thickness was adjusted to 0.7 mm. After shape processing was performed on the edge surface of this disk-shaped glass plate such that the chamfering width was 0.15 mm and the chamfering angle was 45 degrees so as to obtain an inner circumferential side edge surface and an outer circumferential side edge surface, edge surface polishing processing was carried out. In the shape processing, first, a formed grindstone was used to perform rough processing by means of grinding processing without inclining the grindstone, the grindstone was changed, and

finishing processing by means of helical grinding processing with an inclination of 3 degrees was performed.

Thereafter, various types of edge surface polishing processing were performed on the side wall surface and the chamfered surfaces of the glass substrate that has undergone the shape processing. The edge surface of the glass substrate 11 and the mass 20 have the same rotation direction at a processing point at which the edge surface and the mass 20 come into contact with each other. Note that processes other than the edge surface polishing processing were performed with the content of the above-described embodiment, and a magnetic-disk glass substrate was manufactured.

Specifically, as processes performed after the edge surface polishing processing,

- First polishing (performed using cerium oxide (d50: 1 μm) and hard polyurethane polishing pads),
- Chemical strengthening processing,
- Second polishing (performed using colloidal silica (d50: 30 nm) and soft polyurethane polishing pads), and
- Cleaning processing

were performed in the stated order, and thus the magnetic-disk glass substrate was manufactured. The manufactured magnetic-disk glass substrate is a nominal 2.5-inch magnetic-disk glass substrate having an outer diameter of approximately 65 mm, an inner diameter of approximately 20 mm, and a thickness of approximately 0.635 mm.

In the edge surface polishing processing, the ratio of a polishing rate for the side wall surface with respect to a polishing rate for the chamfered surface was obtained by fixing the average particle size d50 of magnetic particles at 2 μm , variously changing the average particle size d50 of the polishing abrasive particles, and modifying the particle size ratio. In the edge surface polishing processing, the inner circumferential side edge surface was a polishing target.

The used magnetorheological fluid had a viscosity of 1000 (mPa•sec) at room temperature (20°C).

Fe particles were used as the magnetic particles, and zirconia particles were used as the polishing abrasive particles.

5 The ratio of polishing rates was obtained from polishing machining allowance amounts at central portions of the side wall surface and the chamfered surface that had undergone edge surface polishing for 3 minutes.

Table 1 shows the results of the particle size ratio and the polishing rate ratio.

10 [0055] [Table 1]

	Particle size ratio (polishing abrasive particles/magnetic particles)	Polishing rate ratio (chamfered surface/side wall surface)
Sample 1	3.00	0.30
Sample 2	1.75	0.45
Sample 3	1.08	0.59
Sample 4	0.70	0.65
Sample 5	0.60	0.80
Sample 6	0.40	0.85
Sample 7	0.30	0.86

[0056] According to this, in order to set the polishing rate ratio to 0.8 or more for making the polishing rates for the side wall surface and the chamfered surface approximately the same, it is understood that the particle size ratio is preferably set to 0.6 or less. Setting the particle size ratio to 0.4 or less is more preferable because the polishing rate ratio can be set to 0.85 or more. Results similar to those of the above-described inner circumferential side edge surface were obtained in the polishing of the outer circumferential side edge surface.

[0057] Also, an index for the polishing rate for the side wall surface was obtained by fixing the average particle size d50 of the magnetic particles at 5 μm , variously changing the average particle size d50 of the polishing abrasive particles, and modifying the particle size ratio. The index for the polishing rate was such that the polishing rate of Sample 8, which will be described later,

having a particle size ratio of 1.20 was 1.00. The index for the polishing rate signifies that the smaller the polishing rate, the smaller the index is.

Fe particles were used as the magnetic particles, and zirconia particles were used as the polishing abrasive particles.

5 The polishing rate ratio was obtained from polishing machining allowance amounts at central portions of the side wall surface and the chamfered surface that had undergone edge surface polishing for 3 minutes.

Table 2 shows the results of the particle size ratio and the polishing rate ratio.

10 [0058] [Table 2]

	Particle size ratio (polishing abrasive particles/magnetic particles)	Index for polishing rate for side wall surface
Sample 8	1.20	1.00
Sample 9	0.60	0.97
Sample 10	0.20	0.93
Sample 11	0.10	0.80

[0059] From Table 2, it is understood that if the particle size ratio is reduced, the polishing rate for the side wall surface decreases. In order to ensure that the index for the polishing rate for the side wall surface is 0.80 or more, the
15 particle size ratio is preferably 0.1 or more. In particular, in order to efficiently perform the edge surface polishing processing, the particle size ratio is more preferably 0.2 or more.

[0060] As described above, although a method for manufacturing a magnetic-disk glass substrate according to the present invention has been
20 described in detail, the present invention is not limited to the above-described embodiment and variations, and it will be appreciated that various improvements and modifications can be made without departing from the gist of the present invention.

25 [List of Reference Numerals]

[0061] 10 Apparatus

5	11	Glass substrate
	11a	Side wall surface
	11b	Chamfered surface
	12, 14	Magnet
	16	Spacer
	20, 62	Mass

CLAIMS

1. A method for manufacturing a magnetic-disk substrate, comprising edge surface polishing processing for polishing an edge surface that includes a side wall surface of a disk-shaped substrate and a chamfered surface provided between the side wall surface and a main surface of the substrate simultaneously, using magnetic functional fluid containing polishing abrasive particles and magnetic particles,

wherein before the edge surface polishing processing, a relationship between a ratio of a particle size of polishing abrasive particles with respect to a particle size of magnetic particles, and a ratio of a polishing rate for a chamfered surface of a substrate with respect to a polishing rate for a side wall surface of the substrate when an edge surface of the substrate is polished using magnetic functional fluid containing the magnetic particles and the polishing abrasive particles that have the ratio of the particle sizes is acquired in advance, the ratio of the particle sizes is set based on a target ratio of a polishing rate for the side wall surface and a polishing rate for the chamfered surface of the substrate that is to be subjected to the edge surface polishing processing, and magnetic functional fluid containing magnetic particles and polishing abrasive particles that achieve the set ratio of the particle sizes is produced,

in the edge surface polishing processing,

a mass of the magnetic functional fluid is formed by a magnetism generation means, and

the edge surface of the substrate that is subjected to the edge surface polishing processing is polished by moving the edge surface of the substrate relative to the mass in a state in which the edge surface is in contact with the mass.

2. The method for manufacturing a magnetic-disk substrate according to claim 1, wherein

the ratio of the particle sizes in the magnetic functional fluid used in the edge surface polishing processing is 0.6 or less.

3. A method for manufacturing a magnetic-disk substrate, comprising edge surface polishing processing for polishing an edge surface that includes a side wall surface of a disk-shaped substrate and a chamfered surface provided between the side wall surface and a main surface of the substrate simultaneously, using magnetic functional fluid containing polishing abrasive particles and magnetic particles,

wherein in the edge surface polishing processing,
a mass of the magnetic functional fluid is formed by a magnetism generation means,

the edge surface of the substrate that is subjected to the edge surface polishing processing is polished by moving the edge surface of the substrate relative to the mass in a state in which the edge surface is in contact with the mass, and

a ratio of a particle size of the polishing abrasive particles with respect to a particle size of the magnetic particles in the magnetic functional fluid used in the edge surface polishing processing is 0.6 or less.

4. The method for manufacturing a magnetic-disk substrate according to any one of claims 1 to 3, wherein

the ratio of the particle sizes in the magnetic functional fluid used in the edge surface polishing processing is 0.1 or more.

5. The method for manufacturing a magnetic-disk substrate according to any one of claims 1 to 4, wherein

an average particle size d₅₀ of the polishing abrasive particles is in a range of 0.1 to 10 μm.

6. The method for manufacturing a magnetic-disk substrate according to any one of claims 1 to 5, wherein

an average particle size d50 of the magnetic particles is in a range of 0.5 to 20 μm .

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7. The method for manufacturing a magnetic-disk substrate according to any one of claims 1 to 6, wherein

a relative speed of a circumferential speed of the substrate relative to the magnetic slurry at a position where the substrate is in contact with the magnetic functional fluid is 50 to 500 m/minute.

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8. The method for manufacturing a magnetic-disk substrate according to any one of claims 1 to 7, wherein

the substrate is a stacked substrate of a substrate stacked body obtained by stacking a plurality of substrates through attaching their main surfaces to each other, and in the edge surface polishing processing, edge surfaces of the stacked substrates of the substrate stacked body are polished simultaneously.

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