

DESCRIPTION

Title of Invention

METHOD FOR MANUFACTURING MAGNETIC-DISK GLASS SUBSTRATE,
5 METHOD FOR MANUFACTURING MAGNETIC DISK, AND DEVICE FOR
POLISHING EDGE SURFACE OF MAGNETIC-DISK GLASS SUBSTRATE

Technical Field

[0001]

10 The present invention relates to a method for manufacturing a
magnetic-disk glass substrate used in a magnetic disk to be provided in a
magnetic recording device such as a hard disk drive (HDD) and the like and a
method for manufacturing a magnetic disk.

15 Background Art

[0002]

Magnetic disks are one type of information recording medium provided
in magnetic recording devices such as HDDs. Magnetic disks are configured
with a thin film such as a magnetic layer formed on a substrate, and
20 conventionally an aluminum substrate has been used as the substrate.
However, recently, in response to the pursuit of high recording density, glass
substrates with which the gap between the magnetic head and the magnetic disk
can be made narrower than with aluminum substrates have been increasingly
used. The glass substrate surface is precisely polished such that the flying
25 height of the magnetic head can be lowered as much as possible to achieve a
high recording density. In recent years, demand for HDDs with a larger storage
capacity and at lower cost has been increasing, and in order to achieve this,
further quality improvement of magnetic-disk glass substrates and cost reduction

are also required.

[0003]

Magnetic-disk glass substrates are usually manufactured by sequentially performing a shape processing (edge surface grinding and chamfering) step, an
5 edge surface polishing step, a main surface grinding step, a main surface polishing step, a chemical strengthening step, and the like on glass substrates formed in a disk shape.

Magnetic disks with which it is possible to achieve a high recording density at low cost as described above are required and high processing
10 accuracy is required for the glass substrates in order to increase the recording density of the magnetic disks. The same applies to not only the main surfaces of the glass substrates but also the shapes of the edge surfaces thereof.

[0004]

As disclosed in Patent Literature 1 below, conventionally, the edge
15 surface of the magnetic-disk glass substrate has generally been processed by performing edge surface brushing after performing edge surface grinding using a formed grindstone.

Also, Patent Document 2 below discloses a method of polishing the edge surface of a magnetic-disk glass substrate by applying a magnetic field to a
20 slurry containing ferrite-based magnetic particles and polishing abrasive particles.

Also, Patent Document 3 discloses a magnetic polishing method of rotating a magnetic electrode disposed apart from the processing surface of a workpiece and the workpiece relative to each other and processing the
25 workpiece with abrasive particles held by a magnetic fluid (magnetic powder) attracted by a magnetic electrode.

Prior Art Document

Patent Document

[0005]

Patent Document 1: JP-A-H11-28649

Patent Document 2: JP-A-2005-50501

5 Patent Document 3: JP-A-2004-291208

Summary of the Invention

Problem to be Solved by the Invention

[0006]

10 As described above, magnetic disks with which it is possible to achieve a high recording density at low cost are required, and in order to achieve this, with regard to the edge surfaces of substrates, it is necessary to achieve both an increase in the quality based on demand to reduce contamination factors such as the occurrence of corrosion on the main surface of a medium, and the
15 improvement of shape accuracy for a decrease in disk fluttering (vibration).

[0007]

However, with the method of processing the edge surface of a glass substrate by performing edge surface brushing after performing edge surface grinding with the above-described conventional formed grindstone, in mass
20 production processing, edge angles between chamfered surfaces and side wall surfaces of the substrate edge surfaces in particular vary significantly between substrates, and it has been difficult to improve the shape accuracy of the substrate edge surface.

[0008]

25 Also, with the method of polishing the edge surface of a magnetic-disk glass substrate by applying a magnetic field to a slurry containing the ferrite-based magnetic particles and the polishing abrasive particles, which is disclosed in Patent Document 2 above, the chamfered surface and the side wall

surface of the glass substrate edge surface have different processing rates, and thus it is difficult to finish both the chamfered surface and the side wall surface to mirror surfaces within a predetermined processing time. In this case, if both the chamfered surface and the side wall surface are processed to mirror surfaces, issues such as extension of a processing time, and deterioration of shape accuracy arise. Also, Patent Document 3 above does not disclose polishing the edge surface of a magnetic-disk glass substrate.

[0009]

In recent years, from the viewpoint of further increasing an information recording density and the like, demand for quality in the magnetic-disk glass substrate, such as accuracy of the shape of the edge surface of the glass substrate and quality in a surface finished by chamfering, has further increased from before, and there is a problem in that in the case where a large number of magnetic-disk glass substrates are manufactured on the basis of mass production using a conventional grinding method and polishing method, it has become difficult progressively to stably meet the increasing demand for quality in the glass substrate.

[0010]

In view of this, from the viewpoint of meeting demand for increasing the recording density of a magnetic disk in which reliability for achieving a high recording density urgently needs to be secured, an object of the present invention is to provide a method for manufacturing a magnetic-disk glass substrate that particularly enables stable processing according to which the edge surface of a magnetic-disk glass substrate can be finished to a highly accurate shape and high quality, and a method for manufacturing a magnetic disk using the glass substrate provided by this method.

Means to Solve the Problem

[0011]

In order to resolve the above-described issues, the present invention has the following aspects.

(Aspect 1)

5 A method for manufacturing a magnetic-disk glass substrate, including edge surface processing for processing an edge surface of a disk-shaped glass substrate having main surfaces, in which the edge surface processing includes edge surface polishing processing for: forming magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing
10 each other, and causing the magnetic field lines to hold a magnetic slurry containing magnetic particles and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines; and bringing the edge surface of the glass substrate into contact with the mass of the magnetic slurry in a state in which the main surfaces of the glass substrate are inclined with
15 respect to a plane direction orthogonal to directions of the magnetic field lines, and simultaneously polishing both a side wall surface of the edge surface of the glass substrate and at least one of chamfered surfaces between the main surfaces and the side wall surface of the glass substrate.

[0012]

20 (Aspect 2)

The method for manufacturing a magnetic-disk glass substrate according to Aspect 1, in which an inclination angle of the glass substrate is in a range of 10 degrees to 45 degrees.

(Aspect 3)

25 The method for manufacturing a magnetic-disk glass substrate according to Aspect 1 or 2, in which an inclination angle of the glass substrate is changed during processing.

(Aspect 4)

The method for manufacturing a magnetic-disk glass substrate according to Aspect 1 or 2, in which an inclination angle of the glass substrate is changed in a continuous or step-wise manner around a processing portion of the glass substrate.

5 [0013]

(Aspect 5)

A method for manufacturing a magnetic-disk glass substrate, including edge surface processing for processing an edge surface of a disk-shaped glass substrate, in which the edge surface processing includes edge surface polishing
10 processing for forming magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing each other, causing the magnetic field lines to hold a magnetic slurry containing magnetic particles and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines, bringing the edge surface of the glass substrate into contact
15 with the mass of the magnetic slurry, and polishing both a side wall surface of the edge surface of the glass substrate and at least one of chamfered surfaces between main surfaces of the glass substrate and the side wall surface, and a first magnetism generating means for polishing mainly the side wall surface of the glass substrate and a second magnetism generating means for polishing
20 mainly the at least one of chamfered surfaces of the glass substrate are used, and the first magnetism generating means and the second magnetism generating means are disposed such that directions of magnetic field lines of the first magnetism generating means and the second magnetism generating means are different from each other.

25 [0014]

(Aspect 6)

A method for manufacturing a magnetic-disk glass substrate, including edge surface processing for processing an edge surface of an disk-shaped glass

substrate, in which the edge surface processing includes edge surface polishing processing for forming magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing each other, causing the magnetic field lines to hold a magnetic slurry containing magnetic particles and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines, bringing the edge surface of the glass substrate into contact with the mass of the magnetic slurry, and polishing both a side wall surface of the edge surface of the glass substrate and at least one of chamfered surfaces between main surfaces of the glass substrate and the side wall surface, and a first magnetism generating means for polishing mainly one chamfered surface of the glass substrate and the side wall surface and a second magnetism generating means for polishing mainly another chamfered surface of the glass substrate and the side wall surface are used, and the first magnetism generating means and the second magnetism generating means are disposed such that directions of magnetic field lines of the first magnetism generating means and the second magnetism generating means are different from each other.

[0015]

(Aspect 7)

The method for manufacturing a magnetic-disk glass substrate according to Aspect 5, in which the second magnetism generating means comprises a magnetism generating means for polishing mainly a chamfered surface between one main surface of the glass substrate and the side wall surface, and a magnetism generating means for polishing mainly a chamfered surface between another main surface of the glass substrate and the side wall surface, and the magnetism generating means are disposed such that the directions of the magnetic field lines of the magnetism generating means are different from each other.

(Aspect 8)

The method for manufacturing a magnetic-disk glass substrate according to any of Aspects 1 to 7, in which grinding processing for forming both the chamfered surfaces and the side wall surface on the edge surface of the glass substrate is performed before the edge surface polishing processing, and the grinding processing includes grinding processing for causing a grindstone to come into contact with the edge surface of the glass substrate in a state in which a rotation axis of the grindstone is inclined with respect to an axis orthogonal to the main surfaces of the glass substrate, and grinding the edge surface of the glass substrate.

10 [0016]

(Aspect 9)

A method for manufacturing a magnetic disk, in which at least a magnetic recording layer is formed on a magnetic-disk glass substrate that is manufactured with the method for manufacturing a magnetic-disk glass substrate according to any of Aspects 1 to 8.

15 [0017]

(Aspect 10)

A device for polishing an edge surface of a magnetic-disk glass substrate, which is used in edge surface polishing processing for forming magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing each other, causing the magnetic field lines to hold a magnetic slurry containing magnetic particles and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines, bringing an edge surface of a disk-shaped glass substrate into contact with the mass of the magnetic slurry, and polishing both a side wall surface of the edge surface of the glass substrate and at least one of chamfered surfaces between main surfaces of the glass substrate and the side wall surface, and the device comprises a first magnetism generating means for polishing mainly the side wall

surface of the glass substrate and a second magnetism generating means for polishing mainly the at least one of chamfered surfaces of the glass substrate, and the first magnetism generating means and the second magnetism generating means are disposed such that directions of magnetic field lines of the first magnetism generating means and the second magnetism generating means are different from each other.

(Aspect 11)

A device for polishing an edge surface of a magnetic-disk glass substrate, which is used in edge surface polishing processing for forming magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing each other, causing the magnetic field lines to hold a magnetic slurry containing magnetic particles and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines, bringing an edge surface of a disk-shaped glass substrate into contact with the mass of the magnetic slurry, and polishing both a side wall surface of the edge surface of the glass substrate and at least one of chamfered surfaces between main surfaces of the glass substrate and the side wall surface, and the device comprises a first magnetism generating means for polishing mainly one chamfered surface of the glass substrate and the side wall surface and a second magnetism generating means for polishing mainly another chamfered surface of the glass substrate and the side wall surface, and the first magnetism generating means and the second magnetism generating means are disposed such that directions of magnetic field lines of the first magnetism generating means and the second magnetism generating means are different from each other.

Brief Description of the Drawings

[0018]

FIG. 1 is a cross-sectional view showing an edge surface shape of a

magnetic-disk glass substrate.

FIGS. 2 (a) to 2(c) are diagrams for illustrating edge surface polishing processing according to the present invention.

FIG. 3 is a perspective view for illustrating edge surface polishing processing according to the present invention.

FIG. 4 is a schematic diagram for illustrating an embodiment in a state in which edge surface polishing processing according to the present invention is performed.

FIGS. 5(a) and 5(b) are schematic diagrams for illustrating another embodiment in a state in which the edge surface polishing processing according to the present invention is performed.

Mode for Embodying the Invention

[0019]

Hereinafter, an embodiment for carrying out the present invention will be described in detail.

FIG. 1 is a cross-sectional view of an outer circumferential side edge portion of a magnetic-disk glass substrate 1 to which the present invention is applied. The glass substrate 1 is formed into an overall disk shape with a circular hole in the central portion, and has front and back main surfaces 11 and 11, an outer circumferential side edge surface and an inner circumferential side edge surface that are formed between these main surfaces 11 and 11, although this is not shown in FIG. 1.

[0020]

The outer circumferential side edge surface of the above-described glass substrate 1 is formed into a shape constituted by a side wall surface 12a orthogonal to the main surface 11, two chamfered surfaces (chamfered surfaces) that are respectively formed between the side wall surface 12a and the

front and back main surfaces 11 and 11. Also, similarly to the outer circumferential edge surface the inner circumferential side edge surface of the above-described glass substrate 1, although not shown, is formed into a shape constituted by a side wall surface orthogonal to the main surface 11 and two
5 chamfered surfaces (chamfered surfaces) formed between the side wall surface and the front and back main surfaces 11 and 11.

[0021]

In the case of a 2.5-inch magnetic disk, for example, the glass substrate 1 is finished to have an outer diameter of 65 mm and an inner diameter of 20 mm.
10 Here, the inner diameter refers to the diameter of a circular hole in the central portion of the glass substrate 1.

[0022]

The main surfaces 11, the outer circumferential side edge surface and the inner circumferential side edge surface of the magnetic-disk glass substrate
15 1 are all finally polished (mirror-polished) to have respective predetermined surface roughnesses. The outer circumferential side edge surface and the inner circumferential side edge surface of the glass substrate 1 are each finished to an edge surface shape as described above, and usually need to be finished to a mirror surface having a surface roughness Rz of 0.1 μm or less and a surface
20 roughness Ra of 0.01 μm or less.

[0023]

Usually, the magnetic-disk glass substrate 1 is manufactured by sequentially performing an edge surface grinding and polishing (mirror polishing) step, a main surface grinding and mirror-polishing step, a chemical
25 strengthening step, and the like on a glass substrate (glass disk 10) that is molded into a predetermined disk shape by direct pressing, for example.

It should be noted that in the present invention, for convenience of illustration, a glass disk molded into a predetermined disk shape by direct

pressing or the like, and a glass substrate, which is a final product that is produced by performing processing, a treatment, and the like on this glass substrate are both called glass substrate or magnetic-disk glass substrate.

[0024]

5 First, the above-described edge surface grinding processing step will be described.

Usually, the above-described edge surface grinding processing can be performed using a so-called formed grindstone.

10 This formed grindstone is formed into a disk shape having a predetermined size, and has a groove for forming the edge surface shape of a glass substrate, and specifically, has a groove according to which the shapes of both a side wall surface and chamfered surfaces can be transferred to the outer circumferential side edge surface of the glass substrate. This formed grindstone is formed into a predetermined dimensional shape, taking a final
15 target dimension and shape of a grinding processing surface of the glass substrate into consideration.

[0025]

For example, a so-called electrodeposition bond grindstone, which is a highly durable grindstone obtained by fixing diamond abrasive particles, with an
20 electrodeposition bond is preferable for rough grinding processing as the formed grindstone used in the above-described edge surface grinding processing. Also, a resin bond grindstone in which a binder that binds abrasive particles is a resin material such as a phenol resin, a urethane resin, a polyimide resin, a polyester resin, or a fluorocarbon resin, a metal bond grindstone in which the
25 binder is a metallic binding agent such as a copper-based alloy, a cast iron-based alloy, a titanium-based alloy, or the like, a vitrified grindstone in which the binder is a glass binding agent, or the like is preferable for final precision grinding processing, and a composite grindstone in which these binding agents

are mixed may also be used. Among these grindstones, a resin bond grindstone whose hardness can be relatively easily adjusted is particularly preferable. Also, alumina abrasive particles, cubic boron nitride abrasive particles, and the like may be used as the abrasive particles.

5 [0026]

Also, abrasive particles having an average particle diameter of 30 μm or less as the particle diameter of the abrasive particles is preferable for maintaining the grinding performance while maintaining roughness over the life of grindstone, and abrasive particles having an average particle diameter of 2 to 10 15 μm are preferable for precision grinding processing, in particular. Diamond abrasive particles are preferable as the abrasive particles, for example. The particle diameter of the abrasive particle can be measured with an electrical resistance test method, for example.

[0027]

15 With the edge surface grinding processing using the above-described formed grindstone, processing is performed in an arrangement relationship such that the glass substrate and the grindstone are in the same plane. In this case, it is preferable to perform processing while respectively rotating the grindstone and the glass substrate in predetermined directions, and it is sufficient that 20 circumferential speeds of the grindstone and the glass substrate and a circumferential speed ratio are set as appropriate so as to be preferable for grinding performed on the inner and outer circumferential side edge surfaces. The rotation directions of the grindstone and the glass substrate in a processing portion may be the same direction (counter direction) or different directions 25 (anti-counter directions).

[0028]

Also, a glass material has a processing characteristic of being influenced easily by heat generated at the time of grinding processing, and therefore, in

order to enable stable grinding processing, it is desirable to increase the cooling effect of a grinding liquid (coolant) supplied to an edge surface portion of the glass substrate, and reduce the influence of the heat generated at the time of grinding processing as much as possible. Although there is no particular
5 limitation on the grinding liquid (coolant) used in the present invention, a soluble grinding liquid that is highly safe for a production site and has a high cooling effect is particularly preferable.

[0029]

Although the shapes of the chamfered surfaces and the side wall
10 surface of the substrate edge surface can be fabricated by grinding processing using the above-described formed grindstone, it is preferable to apply, as a precision grinding processing method after rough grinding processing is performed with the formed grindstone, for example, a method for performing grinding processing on an edge surface of the glass substrate by bringing the
15 grindstone into contact with the edge surface of the glass substrate in a state in which the rotation axis of the grindstone is inclined with respect to the axis orthogonal to the main surface of the glass substrate.

[0030]

For example, the precision grinding processing is performed on a glass
20 substrate in which both the side wall surfaces and the chamfered surfaces are formed on the inner and outer circumferential side edge surfaces by the rough grinding processing using the formed grindstone, in a state in which the grindstone is inclined. The grindstone used in this case is formed into a disk shape having a predetermined size, and the surface on the outer circumferential
25 side of the grindstone that comes into contact with the edge surface of the glass substrate has a groove shape and a recessed shape that is recessed inwardly in a cross-sectional view, for example. Unlike the above-described formed grindstone, shape transfer is performed with a portion of the groove shape.

The above-described resin bond grindstone is preferably applied as the grindstone used in a processing method for performing precision grinding in a state in which the grindstone is inclined with respect to the glass substrate.

[0031]

5 In this case as well, it is preferable to perform processing while the grindstone and the glass substrate are rotated in respective predetermined directions, and it is sufficient that the circumferential speeds of the grindstone and the glass substrate and a circumferential speed ratio are set as appropriate so as to be preferable for processing the inner and outer circumferential side
10 edge surface. The rotation directions of the grindstone and the glass substrate in the processing portion may be the same direction (counter direction) or different directions (anti-counter directions).

[0032]

 In the case of this processing method, by causing the grindstone to
15 come into contact with the edge surface of the glass substrate in a state in which the rotation axis of the grindstone is inclined with respect to the axis orthogonal to the main surface of the glass substrate, the edge surface of the glass substrate and the grindstone are brought into contact with each other such that the locus of the grindstone that comes into contact with the edge surface of the
20 glass substrate is not constant, and the processing is performed.

 With this processing method, the locus of the grindstone that comes into contact with the edge surface of the glass substrate is not constant and a protruding portion (abrasive particles) of the grindstone comes into contact with and acts on the edge surface of the substrate at random positions, and therefore
25 there is little damage on the substrate, and the surface roughness of a grinding processing surface and variation in the surfaces are reduced, as a result of which the grinding processing surface can be finished to a highly smooth surface (semi-mirror surface state) with the above-described formed grindstone.

[0033]

In the present invention, the edge surface polishing processing using a magnetic slurry containing a magnetorheological fluid and polishing abrasive particles is performed subsequently to the above-described edge surface grinding processing. The edge surface polishing processing using this magnetic slurry enables high-quality polishing, and the lower the roughness of the grinding surface after the pretreatment (preprocessing) is, the more the machining allowance of the edge surface polishing processing using the magnetic slurry can be reduced. If the roughness after the grinding processing is high and the machining allowance becomes large, there is a risk that the shape of the edge surface will greatly differ from the shape fabricated in the grinding processing, and the roundness of the edge will be larger than that of the specification, for example. Therefore, as described above, before the edge surface polishing processing using the magnetic slurry, it is preferable to finish the substrate edge surface to a semi-mirror surface state by performing precision grinding on the glass substrate in a state in which the grindstone is inclined with respect to the glass substrate.

[0034]

Next, the edge surface polishing processing of the present invention performed subsequently to the above-described edge surface grinding processing will be described in detail.

An embodiment of the edge surface polishing processing of the present invention is processing for forming linear or arc-shaped magnetic field lines that extend in the thickness direction of the glass substrate using a magnetism generating means constituted by a pair of magnets disposed facing each other, and causing the magnetic field lines to hold a magnetic slurry containing a magnetorheological fluid and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines, and bringing the edge surface

of the glass substrate into contact with the mass of the magnetic slurry in a state in which the main surfaces of the glass substrate are inclined with respect to the plane direction orthogonal to the directions of the magnetic field lines, and simultaneously polishing both a side wall surface of the edge surface of the glass substrate and at least one of chamfered surfaces between the main surfaces and the side wall surface of the glass substrate.

[0035]

FIGS. 2(a) to 2(c) are diagrams for illustrating the edge surface polishing processing according to the present invention. Also, FIG. 3 is a perspective view for illustrating the edge surface polishing processing of the present invention, and FIG. 4 is a schematic diagram for illustrating the state in which the edge surface polishing processing of an embodiment of the present invention is performed.

A device 20 used in the edge surface polishing processing in the present invention polishes the edge surface of the glass substrate using a means for generating magnetism and a magnetic slurry. FIGS. 2(a) to 2(C), and FIGS. 3 and 4 show the case in which polishing is performed on the outer circumferential side edge surface of the glass substrate.

[0036]

To give an overall description of the above-described device 20, as shown in FIG. 2(a), the device 20 includes a pair of magnets 21 and 22, which are permanent magnets, a spacer 23, and an exterior member 24 that has a hollow columnar shape and is made of a non-magnetic material such as stainless steel. The magnets 21 and 22 and the spacer 23 are incorporated into the exterior member 24.

It should be noted that in the case where a contact amount between the magnetic slurry and the glass substrate is to be increased in order to adjust the processing rate and the like, the edge portion of the glass substrate needs to be

inserted between the magnets 21 and 22 to be processed, and thus it is preferable that the exterior member 24 is not provided.

[0037]

After undergoing the above-described edge surface grinding processing, the glass substrate 10 is held by a holder (not shown). The glass substrate 10 held by the holder is brought close to the device 20, and furthermore, a mass 26 of the magnetic slurry (see FIG. 2(c) and FIG. 3), which will be described later, and the outer circumferential side edge surface of the glass substrate 10 are brought into contact with each other. The device 20 and a holder (not shown) for holding the glass substrate 10 are connected to a driving motor (not shown). By rotating the device 20 and the holder to move the outer circumferential side edge surface of the glass substrate 10 and the mass 26 of the magnetic slurry relative to each other, it is possible to polish the outer circumferential side edge surface of the glass substrate 10. For example, the device 20 and the holder for holding the glass substrate 10 (in other words, the glass substrate 10 and the magnets 21 and 22) are rotated in opposite directions (see FIG. 3) preferably at a relative circumferential speed between the device 20 and the glass substrate 10 in the processing portion of 50 to 500 m/minute. At this time, the above-described relative speed is more preferably set to 100 to 400 m/minute because the processing rate is increased. It should be noted that the mass 26 of the magnetic slurry may be fixed, as long as the outer circumferential side edge surface of the glass substrate 10 and the mass 26 of the magnetic slurry can be moved relative to each other.

[0038]

More specifically, the pair of magnets 21 and 22 are close to each other and serve as magnetism generating means, and form magnetic field lines 25 as shown in FIG. 2(b). Each magnetic field line 25 is a linear magnetic field line that extends from the center of the magnets 21 and 22 in the thickness direction

of the glass substrate. In the example shown in FIG. 2(b), a pair of magnets disposed in a separated state in the thickness direction of the glass substrate 10 such that the surface on the N-pole side and the surface on the S-pole side are face each other is used as the magnetism generating means. The spacer 23, which is made of a non-magnetic material, is provided between the magnets 21 and 22 such that the distance between the end surface on the N-pole side of the magnet 21 and the end surface on the S-pole side of the magnet 22 is set to a distance determined in advance. It should be noted that as described above, a mass of the magnetic slurry may be formed between the magnets 21 and 22 and the edge portion of the glass substrate may be brought into contact with the mass without the exterior member 24. The mass 26 of the magnetic slurry is a portion that comes into contact with the outer circumferential side edge surface of the glass substrate 10 and that moves relative to the edge surface, and therefore the magnetic force desirably has a certain degree of strength from the viewpoint of ensuring the rigidity of the mass 26 of the magnetic slurry. Therefore, it is preferable that the distance between the end surface on the N-pole side of the magnet 21 and the end surface on the S-pole side of the magnet 22 is short. However, in the case where the distance is excessively short, it is difficult to insert the glass substrate between the magnets. Therefore, it is preferable that the distance between the end surface on the N-pole side of the magnet 21 and the end surface on the S-pole side of the magnet 22 is set in a certain predetermined range.

[0039]

It should be noted that although permanent magnets are used as a magnetism generating means in the example shown in FIG. 2, electromagnets can also be used, for example. Moreover, although the spacer 23 is used in order to ensure a constant distance between the end surface on the N-pole side of the magnet 21 and the end surface on the S-pole side of the magnet 22, the

magnets 21 and 22 can be fixed to ensure the constant distance between the end surface on the N-pole side of the magnet 21 and the end surface on the S-pole side of the magnet 22 without the spacer 23.

[0040]

5 A magnetorheological fluid in which magnetic particles (microparticles made of magnetic material) are dispersed in a dispersion medium is used as the magnetorheological fluid for the magnetic slurry used in the edge surface polishing. A ferromagnetic material can be used as the magnetic material for particles, and from the point of view of a strong magnetic force, particles
10 containing iron element (Fe) are preferable. Also, a mixture of iron-based ferromagnetic material and non-iron-based ferromagnetic material may be used. The particle diameter of the particles of the magnetic material is preferably in a range of 0.1 to 10 μm . By setting the particle diameter in the above-described range, polishing abrasive particles can be preferably maintained. A non-polar
15 oil or polar oil can be preferably used as the dispersion medium. In the case where a non-polar oil or polar oil is used as the dispersion medium, the non-polar or polar oil preferably has a viscosity of 100 to 1000 (mPa·second) at room temperature (20°C), for example. Also, a surfactant may be added to the magnetorheological fluid.

20 [0041]

Known glass substrate polishing abrasive particles such as cerium oxide, colloidal silica, zirconium oxide, alumina abrasive particles, or diamond abrasive particles can be used as the polishing abrasive particles contained in the magnetic slurry. The polishing abrasive particles have a particle diameter of
25 0.5 to 3 μm , for example. Using the polishing abrasive particles having a particle diameter in this range makes it possible to favorably polish the edge surface of the glass substrate. It is preferable that the polishing abrasive particles are contained in the magnetic slurry in an amount of 3 to 15 vol%, for

example.

[0042]

It is preferable that the concentration of the magnetorheological fluid is adjusted such that the magnetic slurry has a viscosity of 1000 to 2000 mPa·second at room temperature (20°C) because this allows the mass 26 of the magnetic slurry to be formed and edge surface polishing to be efficiently performed. If the viscosity is low (the concentration of the magnetorheological fluid is low), the mass 26 is not readily formed, and it may be difficult to perform polishing by moving the mass 26 and the edge surface of the glass substrate relative to each other in a state in which the mass 26 is pressed against the edge surface. On the other hand, in the case where the magnetic slurry has an excessively high viscosity, it may be difficult to form a uniformly pressed state. Moreover, it is preferable that the magnetic flux density in the magnetism generating means is 0.3 to 0.8 tesla because this allows the mass 26 of the magnetic slurry to be formed and the edge surface polishing to be efficiently performed. Furthermore, the yield stress of the magnetic slurry containing the magnetorheological fluid and the polishing abrasive particles is preferably 30 kPa or more in a state in which the magnetic field of 0.4 tesla is applied, and more preferably 30 to 60 kPa.

20 [0043]

Here, the yield stress (yield shearing stress) of the magnetorheological fluid can be obtained with the following method, for example. A relationship between the shearing speed and the shearing stress of the magnetorheological fluid is obtained using a device obtained by incorporating a magnetic field applying means (e.g., permanent magnets or electromagnets) that can apply a predetermined magnetic field in a rotational viscometer, and the determined relationship between the shearing speed and the shearing stress is approximated using the known Casson's equation, thus making it possible to

obtain the yield stress of the magnetorheological fluid.

[0044]

The above-described yield stress affects the pressure that is applied to the glass substrate from the magnetic slurry, that is, shearing stress when the magnetic slurry held with the magnetic field and the edge portion of the glass substrate are moved relative to each other. Accordingly, the higher the yield stress of the magnetic slurry is (the higher the shearing stress when the magnetic slurry flows is), the more efficiently polishing by the contact between the polishing abrasive particles and the glass substrate is performed, thus making it possible to increase the processing rate.

[0045]

In an embodiment of the edge surface polishing processing in the present invention, polishing is performed by bringing the edge surface of the glass substrate into contact with the mass of the magnetic slurry in a state in which the main surface of the glass substrate is inclined with respect to the plane direction orthogonal to the directions of the magnetic field lines formed by the magnetism generating means constituted by a pair of magnets disposed facing each other. For example, as shown in FIG. 4, the edge surface of the glass substrate is brought into contact with the mass of the magnetic slurry (the magnetic slurry is not shown in FIG. 4) in a state in which a main surface L0 of the glass substrate 10 is inclined by an angle α with respect to a plane direction L1 orthogonal to the directions of the magnetic field lines formed so as to extend linearly between the pair of magnets 21 and 22 disposed facing each other. Then, the above-described operations are performed on two chamfered surfaces to polish the edge surface having a high quality with high precision.

[0046]

For example, in the case where the edge surface of the glass substrate is polished by inserting the glass substrate in the plane direction orthogonal to

the directions of the magnetic field lines without inclining the glass substrate and bringing the edge surface of the glass substrate into contact with the mass of the magnetic slurry, the side wall surface of the glass substrate edge surface has a higher contact pressure with the magnetic slurry than the chamfered surface, and therefore the processing rate for the side wall surface is higher than the processing rate for the chamfered surface, as a result of which the side wall surface is processed faster than the chamfered surface. If the processing rates of the chamfered surface and the side wall surface of the glass substrate edge surface are different from each other, it is difficult to finish both the chamfered surface and the side wall surface to mirror surfaces having the same quality within a predetermined processing time. In this case, if processing is performed until both the chamfered surface and the side wall surface are finished to the same quality, issues such as extension of the processing time and deterioration of the shape accuracy of an edge between the side wall surface that is preferentially processed and the chamfered surface arise.

[0047]

In view of this, in the present invention, inclining the main surface of the glass substrate with respect to the plane direction orthogonal to the directions of the magnetic field lines facilitates contact between the chamfered surface of the substrate edge surface and the magnetic slurry. Accordingly, it is possible to suppress the occurrence of a difference in processing rate between the chamfered surface and the side wall surface of the glass substrate edge surface, and to finish both the chamfered surface and the side wall surface to mirror surfaces having the same quality within a predetermined processing time. As a result, it is possible to perform stable polishing processing by which the shape accuracy of both the chamfered surface and the side wall surface of the glass substrate edge surface, the shape accuracy of an edge between the side wall surface and the chamfered surface can be improved, and the edge surface can

be finished to a high quality with high precision.

[0048]

In the present invention, the inclination angle α of the above-described glass substrate varies slightly depending on a distance between magnets, magnetic flux density, or the like, and it is preferable to set the inclination angle α to be in a range of 10 degrees to 45 degrees, for example. If the inclination angle of the glass substrate is less than 10 degrees, there are cases in which the effect of suppressing the occurrence of a difference in processing rate between the chamfered surface and the side wall surface of the glass substrate edge surface is not obtained. On the other hand, if the inclination angle of the glass substrate is greater than 45 degrees, there are cases in which issues such as deterioration of the radius of curvature of an edge between the main surface and the chamfered surface arise.

[0049]

According to the edge surface polishing processing of the present invention, as described above, it is possible to finish both the chamfered surface and the side wall surface to mirror surfaces having the same quality within a predetermined processing time, and to improve the shape accuracies of both the chamfered surface and the side wall surface of the glass substrate edge surface. For example, variation in the radii of curvature of edges between the chamfered surfaces and the side wall surfaces of glass substrates that have undergone the edge surface polishing processing of the present invention and variation in the radii of curvature of edges between the the main surfaces and the chamfered surfaces of the glass substrates can be preferably suppressed to 0.05 mm or less, and more preferably 0.03 mm or less.

[0050]

Also, the present invention is not limited to an embodiment in which polishing processing is performed in a state in which the inclination angle of the

glass substrate is fixed at a predetermined angle as described above. For example, it is also possible to perform polishing processing while the inclination angle of the glass substrate is changed in a continuous or step-wise manner within a predetermined range (10 degrees to 30 degrees, for example) in a state
 5 in which a processing point (a substrate edge portion that is in contact with the magnetic slurry) of the glass substrate is fixed. Also, for example, it is possible to perform the polishing processing while the inclination angle of the glass substrate is changed in a continuous or step-wise manner in a range of +30 degrees to -30 degrees. In the case where the inclination angle is changed in
 10 a continuous or step-wise manner in this manner, the loci of the polishing abrasive particles do not overlap each other, and therefore the surface roughness after polishing can be reduced. Also, time for changing the angle partway can be omitted, and thus the productivity can be improved.

[0051]

15 It is preferable to set the processing machining allowance of the edge surface polishing processing in the present invention to 1 to 10 μm in terms of a diameter. Also, setting the machining allowance to 5 μm or less is better because the shape accuracy is further increased.

[0052]

20 Although the polishing performed on the outer circumferential side edge surface of the glass substrate 10 has been described, the inner circumferential side edge surface of the glass substrate 10 can also be polished with the same method. That is, a small magnetism generating means, which is described above, is produced and inserted into the circular hole in the center of the glass
 25 substrate 10 and the mass of the magnetic slurry is brought into contact with the inner circumferential side edge surface of the glass substrate 10, thus making it possible to also polish the inner circumferential side edge surface.

[0053]

Also, with the edge surface processing including the edge surface polishing processing using the magnetic slurry in the present invention, it is possible to secure the edge surface quality in a thin plate having a thickness of a glass substrate, which is placed in the edge surface processing, 0.5 mm or less that is equivalent to a thick plate (0.635 mm or more, for example).

[0054]

Next, another embodiment of the edge surface polishing processing of the present invention performed subsequently after the above-described edge surface grinding processing will be described in detail.

Another embodiment of the edge surface polishing processing according to the present invention is processing for forming linear magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing each other, causing the magnetic field lines to hold a magnetic slurry containing a magnetorheological fluid and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines, bringing an edge surface of a glass substrate into contact with the mass of the magnetic slurry, and polishing both a side wall surface of the edge surface of the glass substrate and chamfered surfaces between main surfaces of the glass substrate and the side wall surface, and one configuration of the present embodiment is characterized in that the edge surface of the glass substrate is polished using a plurality of magnetism generating means with magnetic field lines having different directions such that processing rates of the chamfered surface and the side wall surface of the glass substrate edge surface are equivalent to each other.

[0055]

FIG. 5 is a schematic diagram for illustrating another embodiment in a state in which the edge surface polishing processing of the present invention is performed, and shows the case in which an outer circumferential side edge surface of a glass substrate is polished.

It should be noted that a device used in the edge surface polishing processing of the present embodiment is similar to that of the above-described embodiment, and therefore description thereof is omitted.

[0056]

5 In the edge surface polishing processing of the present embodiment, a first magnetism generating means for polishing mainly a side wall surface of the glass substrate and a second magnetism generating means for polishing mainly a chamfered surface of the glass substrate are used, and the first magnetism generating means and the second magnetism generating means are disposed
10 such that directions of magnetic field lines of the first magnetism generating means and the second magnetism generating means are different from each other.

[0057]

 For example, as shown in FIG. 5(a), the above-described first
15 magnetism generating means is disposed such that in a state in which the glass substrate 10 is fixed at a predetermined position during processing, magnetic field lines that are formed so as to extend linearly between a pair of magnets 21 and 22 that constitute the first magnetism generating means and are disposed facing each other can mainly come into contact with the side wall surface of the
20 glass substrate 10, and the side wall surface can be efficiently polished. Also, as shown in FIG. 5(b), the above-described magnetism generating means 2 is disposed such that in a state in which the glass substrate 10 is fixed at the same position as that of FIG. 5(a), magnetic field lines that are formed so as to extend linearly between the pair of magnets 21 and 22 that constitute the second
25 magnetism generating means and are disposed facing each other can mainly come into contact with the chamfered surface of the glass substrate 10 and the chamfered surface can be efficiently polished. It should be noted that the magnetic slurry is not shown in FIG. 5.

[0058]

That is, in the edge surface polishing processing of the present embodiment, the first magnetism generating means for polishing mainly a side wall surface of the glass substrate 10 and the second magnetism generating means for polishing mainly the chamfered surface of the glass substrate 10 are used, and the first magnetism generating means and the second magnetism generating means are disposed such that directions of magnetic field lines thereof are different from each other.

[0059]

For example, in the case in which a glass substrate is inserted in the direction orthogonal to the directions of the magnetic field lines and the edge surface of the glass substrate is brought into contact with a mass of the magnetic slurry to perform polishing (a state similar to (a)), using one magnetism generating means instead of providing a plurality of magnetism generating means with magnetic field lines having different directions, the side wall surface of the glass substrate edge surface has a larger contact amount with the magnetic slurry than the chamfered surface, and therefore the processing rate of the side wall surface becomes greater than the processing rate of the chamfered surface, as a result of which the side wall surface is preferentially processed. If the processing rates of the chamfered surface and the side wall surface of the glass substrate edge surface are different from each other, it is difficult to finish both the chamfered surface and the side wall surface into mirror surfaces having the same quality within a predetermined processing time. In this case, if processing is performed until both the chamfered surface and the side wall surface are finished to the same quality, issues such as extension of the processing time and deterioration of the shape accuracy of the side wall surface that is preferentially processed arise.

[0060]

In the present embodiment, as described above, the first magnetism generating means for polishing mainly the side wall surface of the glass substrate 10 and the second magnetism generating means for polishing mainly the chamfered surface of the glass substrate 10 are used. The first magnetism generating means is disposed such that magnetic field lines that are formed can
5 mainly come into contact with the glass substrate 10 and the side wall surface can be efficiently polished, and the second magnetism generating means is disposed such that magnetic field lines that are formed can mainly come into contact with the chamfered surface of the glass substrate 10 and the chamfered
10 surface can be efficiently polished. Accordingly, the processing rates of the chamfered surface and the side wall surface of the glass substrate edge surface are equivalent to each other, and therefore it is possible to finish the chamfered surface and the side wall surface to mirror surfaces having the same quality within a predetermined processing time. As a result, it is possible to stably
15 perform polishing processing by which the shape accuracies of both the chamfered surface and the side wall surface of the glass substrate edge surface can be improved and the edge surface can be finished to a high quality.

[0061]

Disposing the first magnetism generating means for polishing mainly the
20 side wall surface of the glass substrate 10 and the second magnetism generating means for polishing mainly the chamfered surface of the glass substrate 10 enables processing for simultaneously polishing both the side wall surface and the chamfered surface of the glass substrate 10. It should be noted that although the processing time will be extended, the above-described
25 first magnetism generating means may be firstly used to polish the side wall surface of a glass substrate, and subsequently, the above-described second magnetism generating means may be used to polish the chamfered surface of the glass substrate.

[0062]

Also, in actuality, the edge surface of the glass substrate 10 includes a chamfered surface between one main surface and a side wall surface and a chamfered surface between the other main surface and the side wall surface, and these two chamfered surfaces have different chamfering directions, and therefore, it is desirable that the above-described second magnetism generating means includes a magnetism generating means for polishing mainly the chamfered surface between one main surface and the side wall surface of the glass substrate, and a magnetism generating means for polishing mainly the chamfered surface between the other main surface and the side wall surface, and these two magnetism generating means are disposed such that directions of magnetic field lines of these magnetism generating means are different from each other. That is, in the present embodiment, it is preferable to polish the edge surface of the glass substrate using three magnetism generating means with magnetic field lines having different directions so as to polish one side wall surface and two chamfered surfaces of the glass substrate edge surface. It should be noted that the plurality of magnetism generating means are disposed apart from each other in the circumferential direction of the glass substrate.

[0063]

According to the edge surface polishing processing of the present embodiment, as described above, it is possible to finish the chamfered surface and the side wall surface to mirror surfaces having the same quality within a predetermined processing time by polishing the edge surface of a glass substrate using a plurality of magnetism generating means with magnetic field lines having different directions such that the processing rates of the chamfered surface and the side wall surface of the glass substrate edge surface are equivalent to each other, and it is possible to improve the shape accuracy of both the chamfered surface and the side wall surface of the glass substrate edge

surface. For example, it is possible to suppress variation in radii of curvature of edges between the chamfered surfaces and the side wall surfaces of the glass substrates that have undergone the edge surface polishing processing of the present embodiment and variation in radii of curvature of edges between the main surfaces and the chamfered surfaces of the glass substrates to 0.03 mm or less.

[0064]

The processing machining allowance of the edge surface polishing in the above-described present embodiment is about 1 to 10 μm . Also, setting the machining allowance to 5 μm or less is better because the shape accuracy is further increased.

Also, as another preferable embodiment relating to the above-described present embodiment, a first magnetism generating means for polishing mainly one chamfered surface and the side wall surface of the glass substrate and a second magnetism generating means for polishing mainly the other chamfered surface and the side wall surface are used, and the first magnetism generating means and the second magnetism generating means are disposed such that the directions of magnetic field lines of the first magnetism generating means and the second magnetism generating means are different from each other.

According to the edge surface polishing processing of such an embodiment, it is possible to finish both the chamfered surface and the side wall surface to mirror surfaces having the same quality, and to improve the shape accuracy of both the chamfered surface and the side wall surface of the glass substrate edge surface. Also, there is also an advantage in that two magnetism generating means are sufficient to finish processing with one polishing.

[0065]

Although the polishing performed on the outer circumferential side edge surface of the glass substrate 10 has been described, the inner circumferential

side edge surface of the glass substrate 10 can be polished with the same method. That is, the above-described magnetism generating means is inserted into the circular hole in the center of the glass substrate 10 and the mass of the magnetic slurry is brought into contact with the inner circumferential side edge surface of the glass substrate 10, thus making it possible to also polish the inner circumferential side edge surface.

[0066]

Also, as described above, instead of using a plurality of magnetism generating means with magnetic field lines having different directions, one magnetism generating means can be disposed in the state of FIG. 5(a) and the side wall surface of the glass substrate can be polished, and subsequently, the same magnetism generating means can be disposed in the state of FIG. 5(b) and the chamfered surface of the glass substrate can be polished.

[0067]

Also, relating to the above-described embodiment, the present invention provides an edge surface polishing device for a magnetic-disk glass substrate having the following configurations.

That is, an edge surface polishing device for a magnetic-disk glass substrate is used in edge surface polishing processing for forming magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing each other, causing the magnetic field lines to hold a magnetic slurry containing magnetic particles and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines, bringing an edge surface of a disk-shaped glass substrate into contact with a mass of the magnetic slurry, and polishing both a side wall surface of an edge surface of the glass substrate and at least one of chamfered surfaces between main surfaces of the glass substrate and the side wall surface. The device includes a first magnetism generating means for polishing mainly the side wall surface of the

glass substrate and a second magnetism generating means for polishing mainly a chamfered surface of the glass substrate, and the first magnetism generating means and the second magnetism generating means are disposed such that directions of magnetic field lines of the first magnetism generating means and
5 the second magnetism generating means are different from each other.

Also, provided is an edge surface polishing device for a magnetic-disk glass substrate, which is used in edge surface polishing processing for forming magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing each other, and causing the magnetic field lines to
10 hold a magnetic slurry containing magnetic particles and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines, and bringing an edge surface of a disk-shaped glass substrate into contact with the mass of the magnetic slurry, and polishing a side wall surface of the edge surface of the glass substrate and a chamfered surface between a main
15 surface of the glass substrate and the side wall surface. The device includes a first magnetism generating means for polishing mainly one chamfered surface and a side wall surface of the glass substrate and a second magnetism generating means for polishing mainly the other chamfered surface and a side wall surface of the glass substrate, and the first magnetism generating means
20 and the second magnetism generating means are disposed such that directions of magnetic field lines of the first magnetism generating means and the second magnetism generating means are different from each other.

[0068]

In the present invention, it is preferable that the (type of) glass
25 constituting the glass substrate is aluminosilicate glass. Mirror-polishing the surface of such a glass substrate yields a smooth mirror-finished surface, and the post-processing strength is favorable. For example, aluminosilicate glass containing SiO_2 as a main component and Al_2O_3 in an amount of 20 wt% or less

is preferable. Moreover, glass containing SiO_2 as a main component and Al_2O_3 in an amount of 15 wt% or less is more preferable. Specifically, it is possible to use phosphorus oxide-free amorphous aluminosilicate glass that contains as main components SiO_2 in an amount of 62 wt% or more to 75 wt% or less, Al_2O_3 in an amount of 5 wt% or more to 15 wt% or less, Li_2O in an amount of 4 wt% or more to 10 wt% or less, Na_2O in an amount of 4 wt% or more to 12 wt% or less, and ZrO_2 in an amount of 5.5 wt% or more to 15 wt% or less, and has an $\text{Na}_2\text{O}/\text{ZrO}_2$ weight ratio of 0.5 or more to 2.0 or less and an $\text{Al}_2\text{O}_3/\text{ZrO}_2$ weight ratio of 0.4 or more to 2.5 or less, for example.

10 [0069]

As heat resistant glass, it is preferable to use, for example, glass that contains SiO_2 in an amount of 50 to 75 mol%, Al_2O_3 in an amount of 0 to 5 mol%, BaO in an amount of 0 to 2 mol%, Li_2O in an amount of 0 to 3 mol%, ZnO in an amount of 0 to 5 mol%, Na_2O and K_2O in a total amount of 3 to 15 mol%, MgO , CaO , SrO and BaO in a total amount of 14 to 35 mol%, and ZrO_2 , TiO_2 , La_2O_3 , Y_2O_3 , Yb_2O_3 , Ta_2O_5 , Nb_2O_5 and HfO_2 in a total amount of 2 to 9 mol%, and that has a molar ratio $[(\text{MgO}+\text{CaO})/(\text{MgO}+\text{CaO}+\text{SrO}+\text{BaO})]$ in a range of 0.85 to 1 and a molar ratio $[\text{Al}_2\text{O}_3/(\text{MgO}+\text{CaO})]$ in a range of 0 to 0.30.

Also, it is possible to use glass that contains SiO_2 in an amount of 56 to 75 mol%, Al_2O_3 in an amount of 1 to 9 mol%, alkali metal oxides selected from the group consisting of Li_2O , Na_2O , and K_2O in a total amount of 6 to 15 mol%, alkaline earth metal oxides selected from the group consisting of MgO , CaO , and SrO in a total amount of 10 to 30 mol%, and oxides selected from the group consisting of Gd_2O_3 , Nb_2O_5 and Ta_2O_5 in an amount of more than 0 mol% and 10 mol% or less.

In the present invention, it is preferable that the content of Al_2O_3 in glass composition is 15 wt% or less. Furthermore, it is more preferable that the content of Al_2O_3 is 5 mol% or less.

[0070]

After the above-described edge surface polishing processing of the present invention ends, grinding processing (lapping) for improving the dimensional accuracy and the shape accuracy of this glass substrate is performed on the main surface of this glass substrate. In this grinding performed on main surfaces, a double-side lapping device is generally used to grind the main surfaces of the glass substrate with hard abrasive particles such as diamond particles. By grinding the main surfaces of the glass substrate in this manner, the glass substrate is processed so as to have a predetermined substrate thickness and flatness and to obtain a predetermined surface roughness. It should be noted that this lapping step may be performed on a disk-shaped glass disk produced with the above-described direct pressing method, before the edge surface grinding processing is performed.

[0071]

After the above-described main surface grinding processing ends, mirror-polishing processing for obtaining highly smooth main surfaces is performed.

It is preferable to perform a method for mirror-polishing a glass substrate using a polisher polishing pad made of polyurethane or the like while supplying a slurry (polishing liquid) containing an abrasive that is made of a metal oxide such as cerium oxide or colloidal silica. A glass substrate having a high smoothness can be obtained by performing polishing using a cerium oxide-based abrasive (first polishing processing), and then performing final polishing (mirror-polishing) (second polishing processing) using colloidal silica abrasive particles, for example.

[0072]

Here, Ra and Rz in the present invention refer to the roughness calculated in accordance with Japanese Industrial Standard (JIS) B0601: 2001.

Also, the surface roughnesses (a maximum roughness Rz and an arithmetic mean roughness Ra, for example) of a side wall surface and a chamfered surface in the present invention are values obtained by measuring a surface roughness using a laser microscope in a measurement region of 50 μm ×50 μm at an observation magnification of 3000x.

[0073]

In the present invention, in order to improve the strength of a substrate, chemical strengthening may be performed. As a method for the chemical strengthening, it is preferable to use, for example, a low-temperature

ion-exchange method for performing ion exchange in a temperature range not exceeding the glass transition point. The chemical strengthening is processing in which the glass substrate is brought into contact with a molten chemical strengthening salt so that an alkali metal element having a relatively large atomic radius in the chemical strengthening salt and an alkali metal element having a relatively small atomic radius in the glass substrate are ion-exchanged, and thus the alkali metal element having a relatively large atomic radius permeates through the surface layer of the glass substrate, and compressive stress is generated on the surface of the glass substrate. A glass substrate that has undergone the chemical strengthening has excellent impact resistance, and therefore, it is particularly preferable to mount the glass substrate in an HDD for mobile use, for example. An alkali metal nitrate such as potassium nitrate or sodium nitrate can be preferably used as the chemical strengthening salt.

As described above, a magnetic-disk glass substrate according to the present invention is manufactured.

[0074]

Also, the present invention provides a method for manufacturing a magnetic disk in which the above-described magnetic-disk glass substrate is used. In the present invention, the magnetic disk is manufactured by forming at

least a magnetic layer on the magnetic-disk glass substrate according to the present invention. A hexagonal-system CoCrPt-based or CoPt-based ferromagnetic alloy with a large anisotropic magnetic field can be used as a material of the magnetic layer. It is preferable to form the magnetic layer on the glass substrate by a sputtering method such as a DC magnetron sputtering method. Interposing a base layer between the glass substrate and the magnetic layer makes it possible to control the orientation direction and size of magnetic particles in the magnetic layer. For example, use of a cubic-system base layer made of Cr-based alloy or the like makes it possible to orient, for example, the direction of easy magnetization of the magnetic layer along the magnetic disk surface. In this case, a longitudinal magnetic recording type magnetic disk is manufactured. For example, use of a hexagonal-system base layer containing Ru and Ti makes it possible to orient, for example, the direction of easy magnetization of the magnetic layer along the normal of the plane of the magnetic disk. In this case, the magnetic disk of a perpendicular magnetic recording type is manufactured. The base layer can be formed by a sputtering method in the same manner as the magnetic layer.

[0075]

It is preferable to form a protective layer and a lubricant layer in this order on the magnetic layer. An amorphous hydrogenated carbon-based protective layer is preferable as the protective layer. The protective layer can be formed by a plasma CVD method, for example. As the lubricant layer, a lubricant that has a functional group at the terminal of the main chain of a perfluoropolyether compound can be used. In particular, it is preferable that the lubricant contains, as a main component, a perfluoropolyether compound that has a hydroxyl group as a polar functional group at the terminal. The lubricant layer can be applied and formed by a dipping method.

By using the glass substrate obtained according to the present invention,

the edge surface of the substrate is finished to a high-precision shape and high quality, and therefore it is possible to prevent the occurrence of failure resulting from the surface state of the substrate edge surface, such as measures against corrosion, realize a further increase in the recording density, and obtain a highly reliable magnetic disk.

Working Examples

[0076]

Hereinafter, the embodiment of the present invention will be described in detail by way of working examples. It should be noted that the present invention is not limited to the following working examples.

(Working Examples 1 to 6, Comparative Example 1)

A magnetic-disk glass substrate of this working example was manufactured through (1) a substrate preparation step, (2) a main surface grinding step, (3) an edge surface grinding step, (4) an edge surface polishing step, (5) a main surface polishing step (first polishing step), (6) a chemical strengthening step, and (7) a main surface polishing step (second polishing step) as described below.

[0077]

(1) Substrate preparation step

First, a disk-shaped glass substrate (glass disk) made of aluminosilicate glass and having a diameter of 66 mm ϕ and a thickness of 0.635 mm was obtained from molten glass by direct pressing using upper, lower, and drum molds. It should be noted that a disk-shaped glass substrate may be obtained by cutting a glass sheet formed with a downdraw method or a float method other than using direct pressing. Glass for chemical strengthening containing SiO₂ in an amount of 62 to 75 weight%, ZrO₂ in an amount of 5.5 to 15 wt%, Al₂O₃ in an amount of 5 to 15 weight%, Li₂O in an amount of 4 to 10 weight%, and Na₂O in an amount of 4 to 12 weight% was used as this aluminosilicate glass.

[0078]

(2) Main surface grinding step

This main surface grinding processing was performed using a double-side lapping device, with the glass substrate, which is held by a carrier,
5 being set between the upper and lower surface plates to which diamond pads were attached, and the thickness of the glass substrate was adjusted to be a predetermined thickness.

(3) Edge surface grinding step

Next, a cylindrical grindstone was used to create a hole in the central
10 portion of the glass substrate, and predetermined edge surface grinding (shape processing) was then performed on an outer circumferential edge surface and an inner circumferential edge surface.

In the present working example, after the outer circumferential edge surface of a substrate was chamfered using a formed grindstone, the grinding
15 processing was performed in a state in which the grindstone was inclined with respect to the above-described glass substrate surface so that a chamfered surface and a side wall surface were formed on the substrate edge surface. The shape of the chamfered surface was formed such that an edge was removed so as to make the angle of the chamfered surface with respect to the
20 main surface 45 degrees, and give the chamfered surface a length of 150 μm in the main surface direction and a length of 150 μm in the substrate thickness direction.

It should be noted that the type, particle size, and the like of grindstone were selected as appropriate.

25 The side wall surface and the chamfered surface of the outer circumferential side edge surface of the glass substrate at that time each had a surface roughness R_z of 1.2 μm or less.

Also, a predetermined formed grindstone was used to perform

chamfering processing, with regard to the inner circumferential side edge surface of the substrate.

[0079]

(4) Edge surface polishing step

5 Next, polishing processing was performed on the outer circumferential side edge surface of the glass substrate in which the chamfered surface and the side wall surface were formed on the substrate edge surface by the grinding processing as described above. In the present working example, the polishing processing using a magnetic slurry was performed in accordance with the method shown in FIG. 4 described above.

10 As shown in FIG. 4, a polishing device into which a magnetism generating means constituted by a pair of magnets is incorporated was used to form a mass of magnetic slurry between the two magnets. Then, the edge surface of the glass substrate was polished by rotating these two magnets and the glass substrate. It should be noted that as shown in FIG. 3, the rotation directions of both the device and the glass substrate were set to be opposite to each other (the same directions in a processing portion), and the relative speed of the processing portion was set to 200 m/minute.

20 It should be noted that in addition, in the edge surface grinding step and the edge surface polishing step, the rotation directions, the rotation rate of the grindstone or the mass of the magnetic slurry, the rotation rate of the substrate, a relative ratio of rotation rates of the substrate and the grindstone (or the mass of the magnetic slurry), the magnetic flux density of the magnets, and the like are set as appropriate in a range described in the above-described embodiment.

25 Also, the inclination angle α of the glass substrate was set in a range of five degrees to sixty degrees (see Table 1 below). The diameter of the polishing machining allowance was set to be 10 μm (that is, a depth of 5 μm from the surface), and when 5 μm thereof was polished, the glass substrate was

separated from the device once and the polishing processing was stopped, and then the inclination angle was changed to $-\alpha$ and the polishing was performed on the remaining 5 μm . A substantial polishing processing time was 30 seconds in total.

- 5 Also, as Comparative Example 1, processing was performed similarly to the above, except that the glass substrate was not inclined (an inclination angle of zero degree).

In this manner, the outer circumferential edge surface of the glass substrate was polished. The side wall surface and the chamfered surface of the outer circumferential edge surface of the substrate after the processing each had an R_z of 0.1 μm or less.

Also, a conventional polishing brush was used to polish the inner circumferential side edge surface of the glass substrate.

After undergoing the above-described edge surface polishing as described above, the glass substrate was cleaned.

[0080]

(5) Main surface polishing step (first polishing step)

Next, the first polishing step for removing scratches and distortion remaining from the above-described main surface grinding processing (lapping) was performed using a double-side polishing device. In the double-side polishing device, the glass substrate that is held by a carrier is tightly placed between upper and lower surface plates to which polishing pads have been attached, the carrier is engaged with a sun gear and an internal gear, and the glass substrate is pressed between the upper and lower surface plates. Then, a polishing liquid is supplied between the polishing pads and polishing surfaces of the glass substrate, and the device is rotated, and thereby the glass substrate revolves while rotating on the surface plates so that both surfaces of the glass substrate are polished simultaneously. After undergoing the first polishing step,

the glass substrate was cleaned and dried.

[0081]

(6) Chemical strengthening step

Next, after undergoing the above-described cleaning, the glass
5 substrate was subjected to the chemical strengthening. Chemical
strengthening was performed by preparing a chemical strengthening liquid
obtained by melting a mixture of potassium nitrate and sodium nitrate, and
immersing the glass substrate in the chemical strengthening liquid.

[0082]

10 (7) Main surface polishing step (second polishing step)

Next, the second polishing step was performed using the same
double-side polishing device as used in the above-described first polishing step.
This second polishing step is mirror-polishing processing to finish the main
surfaces of the glass substrate to smooth mirror surfaces having a surface
15 roughness Ra (a measurement value with an atomic force microscope) of 0.2
nm or less, for example, while maintaining the flat surfaces obtained in the first
polishing step described above. After undergoing the above-described second
polishing step, the glass substrate was cleaned and dried.

[0083]

20 The glass substrate having a very smooth main surface was obtained
through the above-described steps. When the surface roughnesses of the
main surface of the glass substrate were measured with an atomic force
microscope (AFM), the glass substrate had a Rz of 1.53 nm and a Ra of 0.13
nm.

25 Also, the obtained glass substrate has an outer diameter of 65 mm, an
inner diameter of 20 mm, and a substrate thickness of 0.635 mm.

In this manner, the magnetic-disk glass substrate of the present
embodiment was obtained.

Thereafter, when roughnesses of the side wall surface and the chamfered surface of the obtained magnetic-disk glass substrate were measured using a laser microscope, and a difference in roughness (R_z) between the chamfered surface and the side wall surface was compared to the case in which the substrate was not inclined, it was found that a difference in roughness (R_z) therebetween was smaller in the case in which the substrate was inclined than in the case in which the substrate was not inclined.

Moreover, with regard to 100 glass substrates produced in a similar manner, as the evaluation for variation in edge angles between the chamfered surfaces and the side wall surfaces in the outer circumferential edge surfaces of the substrates that had undergone the above-described edge surface polishing, variation (Max–Min) in radii of curvature of edge portions (A portions of FIG. 1) between substrates was evaluated by a stylus type outline shape measurement device. First, with regard to one substrate, the radii of curvature of edge portions, namely one from the front side and one from the back side, were measured and the average value thereof was calculated, and the measurement was performed on 100 substrates in a similar manner thereto, and the difference between the maximum value and the minimum value was calculated from 100 sets of the obtained data to obtain variation. Table 1 shows that a case in which variation is 0.03 mm or less is indicated as good, a case in which variation is greater than 0.03 mm and 0.05 mm or less is indicated as fair, and a case in which variation is greater than 0.05 mm is indicated as bad. It should be noted that if variation is 0.05 mm or less, glass substrates are acceptable for practical purposes.

[0084]

Also, with regard to the 100 produced glass substrates, as the evaluation for variation in edge angles between the chamfered surfaces and the main surfaces in the outer circumferential edge surfaces of the substrates that

had undergone the above-described edge surface polishing, variation (Max–Min) in radii of curvature of edge portions (B portions of FIG. 1) was evaluated, similarly to the above, by a stylus type outline shape measurement device. Table 1 shows the results where a case in which variation is 0.02 mm or less is indicated as excellent, a case in which variation is greater than 0.02 mm and 0.03 mm or less is indicated as good, and a case in which variation is greater than 0.03 mm and 0.05 mm or less is indicated as fair.

[0085]

[Table 1]

Table 1	Substrate inclination angle	Variation in radii of curvature of edges between chamfered surfaces and side wall surfaces
Comparative Example 1	zero degree (no inclination)	bad
Working Example 1	5 degrees	fair
Working Example 2	10 degrees	good
Working Example 3	20 degrees	good
Working Example 4	45 degrees	good
Working Example 5	50 degrees	fair
Working Example 6	60 degrees	fair

10

[0086]

[Table 2]

Table 2	Substrate inclination angle	Variation in radii of curvature of edges between main surfaces and chamfered surfaces
Working Example 1	5 degrees	excellent
Working Example 2	10 degrees	excellent
Working Example 3	20 degrees	good
Working Example 4	45 degrees	good
Working Example 5	50 degrees	fair
Working Example 6	60 degrees	fair

[0087]

The following can be found from the results of Tables 1 and 2 above.

1. Inclining the glass substrate in the edge surface polishing processing with the above-described magnetic slurry makes it possible to keep
5 variation in radii of curvature of edges at 0.05 mm or less. Also, in Working Examples 2 to 4 in which polishing processing is performed in a state in which the glass substrate is inclined in a range of 10 degrees to 45 degrees, both variation in radii of curvature of edges of the chamfered surfaces and the side wall surfaces of the glass substrates and variation in radii of curvature of edges
10 of the main surfaces and the chamfered surfaces of the glass substrates was kept at 0.03 mm or less, and thus better shape accuracy was obtained. Also, in Working Example 1 in which the inclination angle is smaller than the above-described range, and Working Examples 5 and 6 in which the inclination angles are greater than the above-described range, large variation in radii of
15 curvature of edges of the chamfered surfaces and the side wall surfaces of the glass substrates slightly increased.

2. In contrast to this, Comparative Example 1 in which the polishing processing is performed without inclining the glass substrate had no issues in variation in radii of curvature of edges of the main surfaces and the chamfered
20 surfaces of the glass substrates, but it was difficult for processing on the chamfered surface side to progress, and therefore variation in radii of curvature of edges of the chamfered surfaces and the side wall surfaces of the glass substrates increased, as a result of which good shape accuracy could not be obtained. As described above, this is thought to be because the processing
25 rates of the chamfered surface and the side wall surface are different from each other, and thus it was not possible to finish both the chamfered surface and the side wall surface to mirror surfaces having the same quality within a predetermined processing time.

[0088]

Also, in Comparative Example 1, regarding the time for finishing both the chamfered surface and the side wall surface to mirror surfaces having the same quality, approximately twice the time in Working Example 3 was needed. In the present invention, a difference in processing rate between the chamfered surface and the side wall surface is small, and thus it is possible to finish both the chamfered surface and the side wall surface to the same quality in substantially same processing times. On the other hand, in the comparative example in which the substrate is not inclined, the processing rates of the chamfered surface and the side wall surface are different from each other, and therefore it is not possible to finish both the chamfered surface and the side wall surface to the same quality in a short time, and thus it is necessary to wait until the chamfered surface having a slow processing rate is finished to a mirror surface, as a result of which the processing time extends.

Also, in Working Example 3 above, when the inclination angle was changed continuously (moved in a reciprocating manner) from +20 degrees to -20 degrees at two seconds per reciprocating motion, variation in radii of curvature of the edges between the chamfered surfaces and the side wall surfaces was evaluated as "excellent".

Also, when the evaluation was carried out under the same condition as that of Table 1, a similar result was obtained.

Also, in the grinding processing that is performed before the edge surface polishing processing, as a result of carrying out the grinding processing without inclining the grindstone with respect to the glass substrate surface (the same polishing machining allowances), the maximum value of the surface roughness Ra of the edge surface slightly increased to 0.12 μm , but the variations in the radii of curvature of the edges were equivalent to each other.

[0089]

(Working Examples A and B, Comparative Example A)

In the edge surface polishing step of Working Example 1 above, polishing processing using a magnetic slurry in accordance with the method shown in FIG. 5 described above was performed in Working Example A.

5 As shown in FIG. 5, a polishing device into which a magnetism generating means constituted by a pair of magnets is incorporated was used to form a mass of magnetic slurry between the two magnets. Then, the edge surface of the glass substrate was polished by rotating these two magnets and the glass substrate. The rotation directions of both the glass substrate and the
10 device were set to be opposite to each other, as shown in FIG. 3.

 Around the glass substrate on which the polishing processing is performed, one magnetism generating means having the above-described configuration (magnetism generating means #1) was disposed at a position shown in FIG 5(a), and another magnetism generating means having the
15 above-described configuration (magnetism generating means #2) was disposed at a position shown in FIG. 5(b), and still another magnetism generating means having the above-described configuration (magnetism generating means #3) was disposed such that the magnetism generating means (#3) is inverted vertically with respect to the magnetism generating means (#2) shown in FIG.
20 5(b) to emit magnetic field lines along the chamfered surface on the lower side in FIG. 5(b).

 It should be noted that in the edge surface grinding step and the edge surface polishing step, the rotation directions, the rotation rate of the grindstone or the mass of the magnetic slurry, the rotation rate of the substrate, a relative
25 ratio of rotation rates of the substrate and the grindstone (or the mass of the magnetic slurry), the magnetic flux density of the magnets, and the like are in a range described in the above-described embodiment.

 In this manner, the side wall surface and the chamfered surface of the

outer circumferential edge surface of the glass substrate were polished simultaneously. The side wall surface and the chamfered surface of the outer circumferential edge surface of the substrate after the processing each had an Rz of 0.1 μm or less.

5 Also, a conventional polishing brush was used to polish the inner circumferential side edge surface of the glass substrate.

After undergoing the above-described edge surface polishing as described above, the glass substrate was cleaned.

[0090]

10 It should be noted that the steps were performed similarly to Working Example 1, except for the above-described edge surface polishing step.

The glass substrate having a very smooth main surface was obtained through the above-described steps. When the surface roughnesses of the main surface of the glass substrate were measured with an atomic force
15 microscope (AFM), the glass substrate had a Rz of 1.53 nm and a Ra of 0.13 nm.

Also, the obtained glass substrate has an outer diameter of 65 mm, an inner diameter of 20 mm, and a substrate thickness of 0.635 mm.

In this manner, the magnetic-disk glass substrate of the present
20 embodiment (Working Example A) was obtained.

Also, a magnetic-disk glass substrate (Working Example B) was obtained similarly to Working Example A above, except that around the glass substrate on which the polishing processing is performed, one magnetism generating means having the above-described configuration was disposed at a
25 position at which one chamfered surface and the side wall surface of the glass substrate are mainly polished, and another magnetism generating means having the above-described configuration was disposed at a position at which the other chamfered surface and the side wall surface of the glass substrate were

polished, to perform the edge surface polishing on the glass substrate.

Also, as a comparative example (Comparative Example A) for the above-described working example, a magnetic-disk glass substrate was obtained similarly to the above-described working example, except that one
5 magnetism generating means was used and a glass substrate was inserted in the direction orthogonal to the directions of magnetic field lines thereof to perform the edge surface polishing on the glass substrate (similar to the state of FIG. 5(a)). It should be noted that in the present comparative example, polishing processing was performed with a polishing time being extended until
10 the surface roughnesses of the side wall surface and the chamfered surface of the glass substrate edge surface were equivalent to each other.

It should be noted that in the above-described comparative example, when prototypes in the case where a polishing time is set to that of the working example were obtained, roughnesses (R_z) of the side wall surface and the
15 chamfered surface of the magnetic-disk glass substrate were measured with a laser microscope, and a difference in roughness (R_z) between the chamfered surface and the side wall surface was compared to that of the working example, it was confirmed that the difference of the working example was smaller than that of the comparative example.

20 [0091]

With regard to 100 glass substrates produced in a similar manner to the above-described working example and comparative example, variation in edge angle between the chamfered surfaces and the side wall surfaces in the outer circumferential edge surfaces of the substrates that had undergone the
25 above-described edge surface polishing and variation in edge angle between the main surfaces and the chamfered surfaces in the outer circumferential edge surfaces of the substrates that had undergone the above-described edge surface polishing were evaluated with the same evaluation method as the

above-described method, and the results thereof are shown in Table 3.

[0092]

[Table 3]

Table 3	Edge surface polishing method	Variation in radii of curvature of edges between chamfered surfaces and side wall surfaces	Variation in radii of curvature of edges between main surfaces and chamfered surfaces
Comparative Example A	one magnetism generating means is used	bad	fair
Working Example A	three magnetism generating means having different directions of magnetic field lines are used	good	good
Working Example B	two magnetism generating means having different directions of magnetic field lines are used	good	good

5

[0093]

The following can be found from the results of Tables 3 above.

1. In Working Example A in which the edge surface of the glass substrate was polished using three magnetism generating means having different magnetic field lines such that processing rates of the chamfered surface and the side wall surface of the glass substrate edge surface were equivalent to each other, it was possible to keep both variation in radii of curvature of edges of the chamfered surfaces and the side wall surfaces of the glass substrates that had undergone the edge surface polishing processing and variation in radii of curvature of edges of the main surfaces and the chamfered surfaces of the glass substrates at 0.03 mm or less, and to obtain a good shape accuracy. Also, a result similar to that of Working Example A was obtained in Working Example B in which two magnetism generating means were used.

2. In contrast to this, in Comparative Example A in which one

magnetism generating means was disposed in the state of FIG. 5(a) and the edge surface polishing was performed on the glass substrate, both the radii of curvature of edges of the chamfered surfaces and the side wall surfaces of the glass substrates and the radii of curvature of edges of the main surfaces and the chamfered surfaces of the glass substrates had large variation, and good shape accuracy could not be obtained. As described above, it is conceivable that this is because the processing rates of the chamfered surface and the side wall surface were different from each other, and processing was performed until both the chamfered surface and the side wall surface were finished to the same quality, as a result of which the shape accuracy deteriorated.

[0094]

Also, in Comparative Example A, regarding the time for finishing both the chamfered surface and the side wall surface to mirror surfaces having the same quality, approximately twice the time in Working Example A was needed. Although the processing rates of the chamfered surface and the side wall surface were equivalent to each other and both the chamfered surface and the side wall surface can be finished to the same quality in the present invention, in the above-described comparative example, the processing rates of the chamfered surface and the side wall surface are different from each other, and it is not possible to finish both the chamfered surface and the side wall surface to the same quality within the same processing time, as a result of which the processing time for finishing the chamfered surface having a slow processing rate extends.

[0095]

25 (Manufacturing magnetic disk)

A magnetic disk for perpendicular magnetic recording was obtained by performing the following film forming step on the magnetic-disk glass substrates obtained in Working Example 3.

Specifically, an adherent layer constituted by a Ti-based alloy thin film, a soft magnetic layer constituted by a CoTaZr alloy thin film, a base layer constituted by a Ru thin film, a perpendicular magnetic recording layer made of a CoCrPt alloy, a carbon protective layer, and a lubricant layer were sequentially
 5 formed on the glass substrate. The protective layer is for preventing degradation of the magnetic recording layer caused by contact with the magnetic head, and the protective layer is composed of hydrogenated carbon and yields wear resistance. Also, the lubricant layer was formed by a dipping method using an alcohol-modified perfluoropolyether liquid lubricant.

10 When the obtained magnetic disk was incorporated into a HDD equipped with a DFH head, and a load and unload durability test was performed for one month while the DFH function was operated under a high temperature and high humidity environment having a temperature of 80°C and a RH of 80%, there was no failure caused by fluttering or corrosion, and a good result was
 15 obtained.

Descriptions of Reference Numerals

[0096]

	1	Magnetic-disk glass substrate
20	10	Disk-shaped glass substrate (glass disk)
	11	Main surface of glass substrate
	12	Outer circumferential edge surface of glass substrate
	12a	Side wall surface
	12b	Chamfered surface
25	20	Edge surface polishing device
	21, 22	Magnets
	23	Spacer
	24	Exterior member

- 25 Magnetic field line
- 26 Mass of magnetic slurry

CLAIMS

1. A method for manufacturing a glass substrate, comprising edge surface processing for processing an edge surface of a glass substrate having main surfaces, wherein the edge surface processing includes edge surface polishing processing for:

forming magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing each other, and causing the magnetic field lines to hold a magnetic slurry containing magnetic particles and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines; and

bringing the edge surface of the glass substrate into contact with the mass of the magnetic slurry in a state in which the main surfaces of the glass substrate are inclined with respect to a plane direction orthogonal to directions of the magnetic field lines, and simultaneously polishing both a side wall surface of the edge surface of the glass substrate and at least one of chamfered surfaces between the main surfaces and the side wall surface of the glass substrate,

wherein an inclination angle of the glass substrate is in a range of 10 degrees to 45 degrees.

2. A method for manufacturing a glass substrate, comprising edge surface processing for processing an edge surface of a glass substrate having main surfaces, wherein the edge surface processing includes edge surface polishing processing for:

forming magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing each other, and causing the magnetic field lines to hold a magnetic slurry containing magnetic particles and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines; and

bringing the edge surface of the glass substrate into contact with the mass of the magnetic slurry in a state in which the main surfaces of the glass substrate are inclined with respect to a plane direction orthogonal to directions of the magnetic field lines, and simultaneously polishing both a side wall surface of the edge surface

of the glass substrate and at least one of chamfered surfaces between the main surfaces and the side wall surface of the glass substrate,

wherein an inclination angle of the glass substrate is changed during processing.

5

3. The method for manufacturing a glass substrate according to claim 1, wherein an inclination angle of the glass substrate is changed in a continuous or stepwise manner around a processing portion of the glass substrate.

10

4. A method for manufacturing a glass substrate, comprising edge surface processing for processing an edge surface of the glass substrate, wherein the edge surface processing includes edge surface polishing processing for forming magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing each other, causing the magnetic field lines to hold a magnetic slurry containing magnetic particles and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines, bringing the edge surface of the glass substrate into contact with the mass of the magnetic slurry, and polishing both a side wall surface of the edge surface of the glass substrate and at least one of chamfered surfaces between main surfaces of the glass substrate and the side wall surface, and

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a first magnetism generating means for polishing mainly the side wall surface of the glass substrate and a second magnetism generating means for polishing mainly the at least one of chamfered surfaces of the glass substrate are used, and

25

the first magnetism generating means and the second magnetism generating means are disposed such that directions of magnetic field lines of the first magnetism generating means and the second magnetism generating means are different from each other.

30

5. A method for manufacturing a glass substrate, comprising edge surface processing for processing an edge surface of the glass substrate, wherein the edge surface processing includes edge surface polishing processing for forming magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing each other, causing the magnetic field lines to hold a magnetic slurry

containing magnetic particles and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines, bringing the edge surface of the glass substrate into contact with the mass of the magnetic slurry, and polishing both a side wall surface of the edge surface of the glass substrate and at least one of chamfered surfaces between main surfaces of the glass substrate and the side wall surface, and

a first magnetism generating means for polishing mainly one chamfered surface of the glass substrate and the side wall surface and a second magnetism generating means for polishing mainly another chamfered surface of the glass substrate and the side wall surface are used, and the first magnetism generating means and the second magnetism generating means are disposed such that directions of magnetic field lines of the first magnetism generating means and the second magnetism generating means are different from each other.

6. The method for manufacturing a glass substrate according to claim 4, wherein the second magnetism generating means comprises a magnetism generating means for polishing mainly a chamfered surface between one main surface of the glass substrate and the side wall surface, and a magnetism generating means for polishing mainly a chamfered surface between another main surface of the glass substrate and the side wall surface, and the magnetism generating means are disposed such that the directions of the magnetic field lines of the magnetism generating means are different from each other.

7. The method for manufacturing a glass substrate according to any of claims 1 to 6, wherein

grinding processing for forming both the chamfered surfaces and the side wall surface on the edge surface of the glass substrate is performed before the edge surface polishing processing, and the grinding processing includes grinding processing for causing a grindstone to come into contact with the edge surface of the glass substrate in a state in which a rotation axis of the grindstone is inclined with respect to an axis orthogonal to the main surfaces of the glass substrate, and grinding the edge surface of the glass substrate.

8. A method for manufacturing a magnetic disk, in which at least a magnetic recording layer is formed on the glass substrate that is manufactured with the method for manufacturing the glass substrate according to any of claims 1 to 7.

5 9. A device for polishing an edge surface of a glass substrate, which is used in edge surface polishing processing for forming magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing each other, causing the magnetic field lines to hold a magnetic slurry containing magnetic particles and polishing abrasive particles so as to form a mass of the magnetic slurry
10 along the magnetic field lines, bringing an edge surface of the glass substrate into contact with the mass of the magnetic slurry, and polishing both a side wall surface of the edge surface of the glass substrate and at least one of chamfered surfaces between main surfaces of the glass substrate and the side wall surface, and
the device comprises a first magnetism generating means for polishing mainly
15 the side wall surface of the glass substrate and a second magnetism generating means for polishing mainly the at least one of chamfered surfaces of the glass substrate, and the first magnetism generating means and the second magnetism generating means are disposed such that directions of magnetic field lines of the first magnetism generating means and the second magnetism generating means are
20 different from each other.

10. A device for polishing an edge surface of a glass substrate, which is used in edge surface polishing processing for forming magnetic field lines using a magnetism generating means constituted by a pair of magnets disposed facing each
25 other, causing the magnetic field lines to hold a magnetic slurry containing magnetic particles and polishing abrasive particles so as to form a mass of the magnetic slurry along the magnetic field lines, bringing an edge surface of the glass substrate into contact with the mass of the magnetic slurry, and polishing both a side wall surface of the edge surface of the glass substrate and at least one of chamfered surfaces
30 between main surfaces of the glass substrate and the side wall surface, and
the device comprises a first magnetism generating means for polishing mainly one chamfered surface of the glass substrate and the side wall surface and a second magnetism generating means for polishing mainly another chamfered surface of the

glass substrate and the side wall surface, and the first magnetism generating means and the second magnetism generating means are disposed such that directions of magnetic field lines of the first magnetism generating means and the second magnetism generating means are different from each other.