

DESCRIPTION

Title of Invention:

METHOD FOR POLISHING GLASS SUBSTRATE, POLISHING LIQUID, METHOD
5 FOR MANUFACTURING GLASS SUBSTRATE, METHOD FOR
MANUFACTURING MAGNETIC-DISK GLASS SUBSTRATE, AND METHOD FOR
MANUFACTURING MAGNETIC DISK

Technical Field

10 [0001]

The present invention relates to a method for polishing a glass substrate that is suitable for manufacturing a magnetic disk provided in a magnetic disk apparatus such as a hard disk drive (HDD), a polishing liquid, a method for manufacturing a glass substrate, a method for manufacturing a magnetic-disk glass
15 substrate, and a method for manufacturing a magnetic disk.

Background Art

[0002]

Magnetic disks are one type of information recording media provided in
20 magnetic recording apparatuses such as hard disk drives (HDDs). Magnetic disks are constituted by forming a thin film such as a magnetic layer formed on a substrate, and an aluminum alloy substrate or a glass substrate has been used as the substrate. Recently, in response to the pursuit of high recording density, glass substrates with which the gap between the magnetic head and the magnetic disk
25 can be made narrower than with aluminum substrates have been increasingly used. Also, the magnetic-disk substrate surfaces are precisely polished such that the flying height of the magnetic head can be lowered as much as possible to achieve a high recording density. In recent years, the demand for HDDs with a larger

storage capacity has been increasing, and in order to achieve this, further quality improvement of magnetic-disk substrates are also required. Therefore, smoother and cleaner substrate surfaces are required.

[0003]

5 As described above, it is essential for a magnetic disk to have a highly smooth surface to achieve the low flying height that is necessary for achieving a high recording density. In order to attain a highly smooth magnetic disk surface, a highly smooth substrate surface is ultimately required, and thus it is necessary to precisely polish the surface of the glass substrate.

10 [0004]

As a conventional method, with regard to polishing, for example, PLT1 discloses an invention according to which when a magnetic-disk substrate made of aluminum is polished using a polishing agent slurry containing aluminum oxide abrasive particles, an inorganic salt selected from water-soluble inorganic
15 aluminum salts and nickel salts, and a water-soluble chelating agent, an insoluble chelating salt produced by reaction with the above-described chelating agent is removed in advance and then the polishing agent slurry is used, as a result of which scratches are reduced.

Also, PLT2 discloses an invention according to which the polishing speed
20 (in particular, sustainability of the polishing speed) and the surface quality (cleanliness) after polishing are increased by polishing a magnetic-disk substrate using a polishing liquid containing an organic reducing agent of phenols or reductons.

25 Prior Art Literature(s)

Patent Literature(s)

[0005]

Patent Literature 1: JP 2000-63806 A

Patent Literature 2: JP 2013-32502 A

Summary of Invention

Problem to be Solved by the Invention

5 [0006]

Conventionally, processing for polishing a main surface of a magnetic-disk substrate has been performed in a plurality of stages, and in general, initial first polishing processing has been performed using cerium oxide as polishing abrasive particles, but according to the studies conducted by the inventor of the present invention, it was found that in the polishing processing using these cerium oxide abrasive particles, the polishing speed was low and the polishing speed during continuous polishing processing significantly decreased, which were obstacles to the realization of mass production of substrates having surfaces with increased quality. Also, the inventor of the present invention conducted studies by applying various conventional polishing techniques, such as the method disclosed in the above-described patent literatures, to the polishing processing using the above-described cerium oxide abrasive particles, but it was difficult to increase the polishing speed. Also, it was difficult to significantly reduce the decrease in the polishing speed during continuous polishing processing. In general, the initial first polishing processing has the largest amount of machining allowance among a plurality of types of polishing processing, and thus the polishing speed is extremely important.

15 [0007]

The present invention was made in order to resolve such conventional issues, and an object thereof is to provide a method for polishing a glass substrate by which the polishing speed can be increased in processing for polishing a main surface of the glass substrate using cerium oxide as polishing abrasive particles. Also, an object thereof is to provide a method for polishing a glass substrate, by

25

which such a polishing speed increase effect can be maintained for a long period of time. In particular, an object thereof is to also provide a polishing method suitable for a magnetic-disk glass substrate.

Also, an object thereof is to provide a polishing liquid that is suitably used in
5 such a method for polishing a glass substrate of the present invention.

Means to Solve the Problem

[0008]

In view of this, the inventor of the present invention searched for a means
10 for resolving the above-described conventional issues, and as a result, the inventor found that the polishing speed was increased due to an alkaline polishing liquid used in polishing processing using cerium oxide as polishing abrasive particles containing an inorganic reducing agent. Also, the inventor found that such a polishing speed increase effect was maintained for a long period of time.

15 As a result of further conducting intensive studies based on the obtained findings, the inventor of the present invention accomplished the present invention. That is, the present invention has the following aspects.

[0009]

(Aspect 1)

20 A method for polishing a glass substrate, by which a surface of a glass substrate is subjected to polishing processing using a polishing liquid containing cerium oxide as polishing abrasive particles, in which the polishing liquid is alkaline and contains an inorganic reducing agent.

[0010]

25 (Aspect 2)

The method for polishing a glass substrate according to Aspect 1, in which the inorganic reducing agent is at least one selected from thiosulfates, phosphinates, dithionites, and sulfites with alkali metals or alkaline earth metals.

[0011]

(Aspect 3)

The method for polishing a glass substrate according to Aspect 1 or 2, in which a pH of the polishing liquid is in a range of 8 to 12.

5 (Aspect 4)

The method for polishing a glass substrate according to any of Aspects 1 to 3, in which the cerium oxide abrasive particles contain lanthanum (La).

[0012]

(Aspect 5)

10 A method for manufacturing a glass substrate, including polishing processing to which the method for polishing a glass substrate according to any of Aspects 1 to 4 is applied.

[0013]

(Aspect 6)

15 A method for manufacturing a magnetic-disk glass substrate, to which the method for manufacturing a glass substrate according to Aspect 5 is applied, in which the glass substrate is a magnetic-disk glass substrate.

[0014]

(Aspect 7)

20 A method for manufacturing a magnetic disk, in which at least a magnetic film is formed on a magnetic-disk glass substrate manufactured using the method for manufacturing a magnetic-disk glass substrate according to Aspect 6.

[0015]

(Aspect 8)

25 A polishing liquid that is to be used in processing for polishing a surface of a glass substrate, in which the polishing liquid is alkaline, contains cerium oxide as polishing abrasive particles, and further contains an inorganic reducing agent.

Effects of the Invention

[0016]

According to the present invention, it is possible to provide a method for polishing a glass substrate by which in processing for polishing a main surface of a glass substrate using cerium oxide as polishing abrasive particles, the polishing speed can be increased. Also, it is possible to provide a method for polishing a glass substrate, by which such a polishing speed increase effect can be maintained for a long period of time. Moreover, the method for polishing a glass substrate of the present invention is particularly suitable for processing for polishing a magnetic-disk glass substrate.

Also, according to the present invention, it is possible to provide a polishing liquid that is suitably used in such a method for polishing a glass substrate of the present invention.

[0017]

Moreover, the magnetic-disk glass substrate obtained by the present invention has a high productivity and can be preferably used as, in particular, a next-generation substrate with stricter requirements on substrate surface quality than currently available substrates. Also, even in the case where the magnetic-disk glass substrate obtained by the present invention is used in combination with a magnetic head that is provided with the DFH function and is designed to have a very low flying height, a highly reliable magnetic disk that is capable of performing stable operations for a long period of time can be obtained.

Brief Description of Drawings

25 [0018]

FIG. 1 is a cross-sectional view of a magnetic-disk glass substrate.

FIG. 2 is an overall perspective view of the magnetic-disk glass substrate.

FIG. 3 is a longitudinal cross-sectional view of a schematic configuration of

a double-side polishing apparatus.

Mode for Embodying the Invention

[0019]

5 Hereinafter, embodiments according to the present invention will be described in detail. In the present embodiment, mainly, a magnetic-disk glass substrate that is suitable as a magnetic-disk substrate will be described.

[0020]

10 The magnetic-disk glass substrate is generally manufactured through processes such as glass substrate molding, drilling processing, chamfering processing, grinding processing, edge surface polishing processing, and main surface polishing processing. Note that the order of processes is not limited to the above.

[0021]

15 The magnetic-disk glass substrate is manufactured by first molding a disk-shaped glass substrate (glass disk) from molten glass through direct pressing. Note that a glass substrate (glass disk) may be obtained by cutting plate glass manufactured using a downdraw method or a float method other than using direct pressing into a predetermined size. Thereafter, drilling processing or chamfering
20 processing is performed as appropriate to produce a disk-shaped glass substrate (glass disk) having a circular hole in the central portion.

[0022]

25 Next, grinding processing for increasing dimensional accuracy and shape accuracy is performed on the above-described disk-shaped glass substrate (glass disk). In this grinding processing, in general, a double-side grinding apparatus is used to grind main surfaces of the glass substrate. 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.

[0023]

After this grinding step ends, edge surface polishing processing through brushing or the like is performed, and then main surface polishing processing for
5 obtaining high precision main surfaces (mirror surfaces) is performed.

In the present invention, as a method for polishing surfaces (edge surfaces and main surfaces) of the glass substrate, polishing is performed using polishing pads made of polyurethane while a polishing liquid containing cerium oxide as polishing abrasive particles is supplied.

10 [0024]

As described above, according to the present invention, in the method for polishing a glass substrate by which surfaces of the glass substrate are subjected to polishing processing using a polishing liquid containing cerium oxide as polishing abrasive particles, the above-described polishing liquid is alkaline and contains an
15 inorganic reducing agent.

[0025]

The above-described polishing liquid used in such polishing processing is obtained through a combination of polishing abrasive particles and water, which is a solvent, and in the present invention, the polishing liquid contains an inorganic
20 reducing agent and other additive agents are added thereto as required.

In order to make up a polishing liquid containing cerium oxide abrasive particles, it is sufficient that pure water is used, and an inorganic reducing agent and other additive agents are added as required to prepare the polishing liquid, for example.

25 [0026]

In the present invention, from the viewpoint of polishing efficiency, it is preferable to use a polishing liquid containing cerium oxide abrasive particles having an average particle diameter of about 0.1 to 2.0 μm . In particular, it is

preferable to use cerium oxide abrasive particles having an average particle diameter of about 0.8 to 1.3 μm .

Note that in the present invention, the above-described average particle diameter denotes a particle diameter at which a cumulative curve reaches 50% when the cumulative curve is obtained by setting the total volume of powder particles in the particle size distribution measured using a light scattering method to 100% (referred to as "cumulative average particle diameter (50% diameter)" hereinafter). In the present invention, specifically, the cumulative average particle diameter (50% diameter) can be measured using a particle diameter/particle size distribution measurement apparatus.

[0027]

Also, although highly pure cerium oxide that contains no impurities can basically be used as the above-described cerium oxide abrasive particles, cerium oxide abrasive particles preferably contain lanthanum (La) in the present invention. Cerium oxide abrasive particles containing lanthanum (La) have a better polishing speed increase effect. The content of lanthanum is expressed as the content of lanthanum oxide (La_2O_3) with respect to TREO (total rare-earth oxides: an amount of oxides of all of the rare earth elements in the polishing agent).

[0028]

With regard to the content of lanthanum when cerium oxide abrasive particles contain lanthanum (La) in this manner, the content of lanthanum oxide (La_2O_3) with respect to TREO is preferably in a range of 1 to 50%, for example. If the content of lanthanum oxide (La_2O_3) is less than 1%, the effect of cerium oxide abrasive particles containing lanthanum (La) is not obtained significantly. Also, if the content of lanthanum oxide (La_2O_3) is greater than 50%, the cerium oxide component becomes relatively low, and the polishing speed decreases in some cases.

[0029]

Although there is no particular limitation on the content of the cerium oxide abrasive particles in the polishing liquid and the content can be adjusted as appropriate, from the viewpoint of the polishing speed and cost, the content is preferably 1 to 20 wt%, for example.

5 [0030]

In the present invention, the polishing liquid that is applied to the above-described polishing processing contains an inorganic reducing agent.

In the present invention, the above-described inorganic reducing agent is preferably at least one type selected from thiosulfates, phosphinates, dithionites,
10 and sulfites with alkali metals (Li, Na, K, Rb, Cs, Fr) or alkaline earth metals (Be, Mg, Ca, Sr, Ba, Ra), for example.

[0031]

It is inferred that the reason why the polishing speed can be increased by adding an inorganic reducing agent to the polishing liquid containing cerium oxide
15 as polishing abrasive particles is as follows.

Inorganic reducing agents, for example, the above-described thiosulfates, are reductive and reduce cerium (tetravalent) to trivalent cerium. Trivalent cerium gives electrons to Si-O of glass and weakens this bonding, and thus the polishing speed increases.

20 [0032]

Also, it is thought that among inorganic reducing agents, the above-described inorganic reducing agent is stable and unlikely to be oxidized under alkaline conditions, and has a long-lasting reducing effect. In particular, thiosulfates have extremely low reactivity to oxygen (strong oxidizing agent), and
25 thus are unlikely to undergo redox reaction with oxygen dissolved in the polishing liquid or oxygen in the air. Thus, even in the case where polishing processing is performed for a long period of time, the reducibility of the inorganic reducing agent in the polishing liquid is unlikely to be impaired. Thus, adding the inorganic

reducing agent of the present invention to the polishing liquid makes it possible to suppress a decrease in the polishing speed during continuous polishing.

Note that the conventional organic reducing agent as described in PLT2 above easily and quickly reacts with oxygen dissolved in the polishing liquid or oxygen in the air and loses the reducing effect, and thus does not have a polishing speed increase effect or a long-lasting polishing speed increasing effect. Also, there are cases where the organic reducing agent decomposes under an alkaline environment.

[0033]

In the present invention, among the above-described inorganic reducing agent, thiosulfates are particularly preferable in light of the fact that thiosulfates are unlikely to react with oxygen and have a large functional effects. Thiosulfates with Na, K, Mg, or Ca are more preferable.

[0034]

The content (addition amount) of the above-described inorganic reducing agent in the polishing liquid is preferably in a range of 0.5 wt% to 10 wt%. If the content is less than 0.5 wt%, the functional effects of the present invention are not obtained sufficiently in some cases. On the other hand, if the content is greater than 10 wt%, the polishing liquid tends to undergo separation, and the polishing speed decreases instead in some cases. The content of the above-described inorganic reducing agent in the polishing liquid is more preferably in a range of 1 wt% to 5 wt%.

[0035]

Also, it is important to use the polishing liquid containing the cerium oxide abrasive particles and the inorganic reducing agent of the present invention in an alkaline condition. Use of the polishing liquid of the present invention in an alkaline condition makes it possible to prevent aggregation and precipitation of cerium oxide microparticles, which are the polishing abrasive particles, increase

the polishing speed, and reduce polishing blemishes. Also, decomposition reaction of the above-described inorganic reducing agent can be suppressed, the polishing liquid is unlikely to be oxidized and is stable and the effect of addition of the above-described inorganic reducing agent lasts longer.

5 [0036]

In the present invention, from the viewpoint of prevention of aggregation and precipitation of polishing abrasive particles and suppression of decomposition reaction of an inorganic reducing agent, the pH of the polishing liquid is preferably in a range of 8 to 12. The pH of the polishing liquid is more preferably in a range
10 of 9 to 11. Although the polishing liquid containing the above-described inorganic reducing agent often has a pH in the above-described range, in some cases, the pH of the polishing liquid may be adjusted by adding an appropriate alkali agent or acid as needed.

[0037]

15 In the present invention, although there is no particular limitation on the polishing method in the polishing processing, it is sufficient that in processing for polishing main surfaces of a substrate, for example, the main surfaces of the glass substrate are polished by bringing the glass substrate and the polishing pads into contact with each other, and moving the polishing pads and the glass substrate
20 relative to each other while supplying the polishing liquid containing the above-described cerium oxide abrasive particles and the inorganic reducing agent, for example.

For example, FIG. 3 is a longitudinal cross-sectional view of a schematic configuration of a planetary double-side polishing apparatus that can be used in the
25 processing for polishing a glass substrate. The double-side polishing apparatus shown in FIG. 3 includes a sun gear 2, an internal gear 3 arranged concentrically on the outside of the sun gear 2, a carrier 4 that is engaged with the sun gear 2 and the internal gear 3 and revolves and rotates in response to the rotation of the sun

gear 2 or the internal gear 3, an upper surface plate 5 and a lower surface plate 6 to which polishing pads 7 that are capable of holding a product 1 to be polished that is held by the carrier 4 are respectively attached, and a polishing liquid supply portion (not shown) that supplies the polishing liquid between the upper surface plate 5 and the lower surface plate 6.

[0038]

At the time of polishing processing, by using such a double-side polishing apparatus, the product 1 to be polished, that is, the glass substrate held by the carrier 4 is held between the upper surface plate 5 and the lower surface plate 6, and both the upper and lower surfaces (main surfaces) of the product 1 to be polished are polished while the polishing liquid is supplied between the polishing pad 7 of the upper and lower surface plates 5 and 6 and the product 1 to be polished and the carrier 4 revolves and rotates in response to the rotation of the sun gear 2 and the internal gear 3. It is preferable to use a resin polisher (made of urethane foam or polyurethane foam) as the above-described polishing pad. Note that from the viewpoint of increasing the polishing speed, it is preferable to use a polishing pad having an Asker C hardness of 75 to 90. Also, from the viewpoint of suppression of minute blemishes caused by polishing, it is preferable to use a suede polishing pad.

[0039]

Also, from the viewpoint of the polishing speed and the polishing quality, the load applied to the substrate during polishing is preferably in a range of 50 to 200 g/cm².

Also, in the present invention, it is preferable to polish both surfaces of a plurality of substrates simultaneously through planetary gear movement by the carrier holding the plurality of substrates simultaneously. In particular, in one instance of polishing processing (one batch), it is preferable to perform the polishing processing on 50 or more substrates simultaneously.

[0040]

Note that in general, processing for polishing main surfaces of substrates is usually performed over two stages, namely, first polishing processing for removing blemishes and warping remaining from grinding processing so as to achieve predetermined smooth surfaces and second polishing processing for finishing the surface roughnesses of the main surfaces of the glass substrates into smooth mirror surfaces (however, there are cases where multi-stage polishing with three or more stages is performed), and in this case, it is preferable to apply the present invention to at least the first polishing processing, which is the preceding stage. In general, the first polishing processing has the largest amount of machining allowance among a plurality of types of polishing processing, and thus the polishing speed is very important. Note that from the viewpoint of reducing the machining allowance and increasing the productivity as much as possible, the surface roughness Ra of main surfaces of a glass substrate on which the first polishing processing is performed is preferably 100 nm or less. Similarly, from the viewpoint of reducing the machining allowance of the second polishing processing, the first polishing processing is preferably performed such that the surface roughness Ra of the main surfaces is 1.5 nm or less.

[0041]

Also, in this case, finishing (precision) polishing processing (second polishing processing), which is performed in the latter stage, is preferably performed using a polishing liquid containing colloidal silica abrasive particles having an average particle diameter of about 10 to 100 nm, for example. In this case, from the viewpoint of increasing the polishing speed, it is appropriate to use a polishing liquid obtained by adjusting the pH to an acidic range. For example, the pH is preferably 5 or less, and more preferably 4 or less. Also, from the viewpoint of reducing an increase in the surface roughness caused by final cleaning, the pH is preferably 1 or more and more preferably 2 or more. Also, a polishing pad

(suede pad) with a soft polisher is preferable as the polishing pad for this finishing polishing. The polishing method is similar to the above.

[0042]

The polishing method of the present invention can be preferably applied to
5 not only the processing for polishing main surfaces of a glass substrate but also processing for polishing edge surfaces of the glass substrate.

Next, processing for polishing edge surfaces of the glass substrate will be described.

[0043]

10 In the edge surface polishing processing, an outer circumferential edge surface 12 (see FIGS. 1 and 2) of a glass substrate 1 is polished using a rotary brush (also referred to as "polishing brush"), for example. Note that a method for polishing chamfered surfaces and a side wall surface formed in an inner circumferential edge surface 13 of the glass substrate 1 is similar to the above, and
15 thus description thereof is omitted.

[0044]

The above-described rotary brush has a rotation axis perpendicular to front and back main surfaces 11 and 11 of the glass substrate 1 and brush hairs attached to an outer circumference of the rotation axis. The rotary brush polishes
20 two chamfered surfaces 12b and 12b and a side wall surface 12a of an outer edge surface 12 of the glass substrate 1 using the brush hairs while rotating about the rotation axis.

[0045]

The polishing liquid is supplied from a nozzle to a site of the glass substrate
25 1 to be polished using the rotary brush. The polishing liquid contains a polishing material, and in the case where the present invention is applied, cerium oxide abrasive particles are used as the polishing material. This polishing liquid is alkaline and contains the above-described inorganic reducing agent.

[0046]

In the edge surface polishing processing, a plurality of glass substrates 1 may be stacked and polished all together. In this case, spacers may be disposed between the glass substrates 1. Also, the above-described rotary brush may swing in a direction in which the glass substrates 1 are stacked (a direction parallel to the center line of the rotation axis) while rotating about the rotation axis.

[0047]

The supply amount of the polishing liquid that is supplied to a portion that is to be polished may be set in a range of 5 to 20 L/min, for example, the rotation speed of the rotary brush may be set in a range of 100 to 500 rpm, for example, the swing speed of the rotary brush in the rotation axis direction may be set in a range of 3 to 10 rpm (3 to 10 reciprocations in one minute), for example, and the rotation speed of the glass substrate (stacked body) may be set in a range of 50 to 100 rpm, for example, as appropriate.

[0048]

Applying the present invention to the processing for polishing edge surfaces of a glass substrate makes it possible to increase the polishing speed and maintain such a polishing speed increase effect for a long period of time. That is, the effect is long-lasting.

[0049]

In the present invention, the type of glass constituting the glass substrate is preferably aluminosilicate glass. Also, the type thereof is more preferably amorphous aluminosilicate glass. Mirror-polishing the surface of such a glass substrate can yield a smooth mirror-finished surface, and the post-processing strength is favorable. Aluminosilicate glass containing SiO_2 in an amount of 58 wt% or more and 75 wt% or less, Al_2O_3 in an amount of 5 wt% or more and 23 wt% or less, Li_2O in an amount of 3 wt% or more and 10 wt% or less, and Na_2O in an amount of 4 wt% or more and 13 wt% or less as main components can be used as

such aluminosilicate glass.

[0050]

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

10 [0051]

In addition, there are cases in which heat resistance is required as a characteristic of a next-generation substrate. Such a glass substrate has a glass transition point (T_g) as high as 600°C or more, for example. Moreover, such a glass substrate has a glass composition in which the alumina (Al_2O_3) amount in the glass components is 8 mol% or less, for example. For example, 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 6 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.

20

[0052]

The present invention is particularly suitable for processing for polishing such a heat resistant glass substrate having a high glass transition temperature (T_g). The heat resistant glass substrate having such a composition has relatively large amounts of Si-O bonds and has a better effect of suppressing a decrease in the polishing speed during continuous polishing processing than the

25

above-described aluminosilicate glass, for example, due to performing polishing processing to which a polishing liquid containing the cerium oxide abrasive particles and an inorganic reducing agent of the present invention is applied.

[0053]

5 Note that in particular, the present invention is suitable for processing for polishing a magnetic-disk glass substrate, and can be applied to substrates other than the magnetic-disk glass substrate, such as an optical lens, a substrate for a mask blank, and a liquid crystal panel, for example.

[0054]

10 In the present invention, an arithmetic average surface roughness Ra of a surface of a glass substrate after final polishing processing is preferably 0.20 nm or less, particularly preferably 0.15 nm or less, and more preferably 0.10 nm or less. Furthermore, the maximum roughness Rmax is preferably 2.0 nm or less, particularly preferably 1.5 nm or less, and more preferably 1.0 nm or less. Note
15 that Ra and Rmax in the present invention refer to roughnesses calculated in conformity with Japanese Industrial Standard (JIS) B0601: 1982. Ra refers to an arithmetic average roughness, and Rmax refers to the maximum height. These surfaces are preferably mirror-surfaces.

 Also, it is preferable in terms of practical application that the surface
20 roughness in the present invention is the surface roughness of a surface shape that is measured using an atomic force microscope (AFM) in a 1 μm ×1 μm range at a resolution of 256×256 pixels, for example. However, if Ra exceeds 50 nm, it is preferable to measure the surface roughness using a stylus type roughness tester.

[0055]

25 In the present invention, it is possible to perform chemical strengthening processing before or after the processing for polishing the main surfaces of the substrate. The glass substrate that has undergone the chemical strengthening processing 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.

[0056]

- 5 As shown in FIGS. 1 and 2, a disk-shaped glass substrate 1 having both main surfaces 11 and 11 with an outer circumferential side edge surface 12 and an inner circumferential side edge surface 13 therebetween can be obtained by manufacturing a magnetic-disk glass substrate including polishing processing to which the method for polishing a glass substrate of the present invention is applied.
- 10 The outer circumferential side edge surface 12 is constituted by a side wall surface 12a and chamfered surfaces 12b and 12b that are each located between a main surface and the side wall surface 12a. The inner circumferential side edge surface 13 also has a similar shape.

[0057]

- 15 As described above, according to the present invention, in the processing for polishing surfaces of a glass substrate using cerium oxide as polishing abrasive particles, the polishing speed can be increased. Also, in addition to this, the polishing speed increase effect is long-lasting and a decrease in the polishing speed during continuous polishing processing can be suppressed effectively. In
- 20 particular, the method for polishing a glass substrate of the present invention is suitable for processing for polishing a magnetic-disk glass substrate.

- Moreover, the magnetic-disk glass substrate obtained by the present invention has a high productivity and can be preferably used as, in particular, a next-generation substrate with stricter requirements on substrate surface quality
- 25 than currently available substrates.

[0058]

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

The magnetic disk is manufactured by forming at least a magnetic film on the magnetic-disk glass substrate obtained by 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 using a sputtering method such as a DC magnetron sputtering method, for example.

[0059]

Also, it is preferable to form a protective layer and a lubricant layer in this order on the magnetic film. An amorphous hydrogenated carbon-based protective layer is preferable as the protective layer. Also, as the lubricant layer, a lubricant containing a perfluoropolyether compound can be used.

Even in the case where the magnetic-disk glass substrate obtained by the present invention is used in combination with a magnetic head that is provided with the DFH function and is designed to have a very low flying height, a highly reliable magnetic disk that is capable of performing stable operations for a long period of time can be obtained.

Working Examples

[0060]

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

[0061]

(Working Example 1)

A magnetic-disk glass substrate of this working example was manufactured through (1) rough grinding processing, (2) shape processing, (3) precision grinding processing, (4) edge surface polishing processing, (5) main surface first polishing processing, (6) chemical strengthening processing, and (7) main surface second

polishing processing as described below.

[0062]

(1) Rough grinding processing

First, a disk-shaped glass substrate made of aluminosilicate glass and
5 having a diameter of 66 mmφ and a thickness of 1.0 mm was obtained from molten
glass by direct pressing using upper, lower, and drum molds. Note that a glass
substrate may be obtained by cutting plate glass manufactured using a downdraw
method or a float method other than using direct pressing into a predetermined size.
Glass that can be chemically strengthened and contains SiO₂ in an amount of 58 to
10 75 wt%, Al₂O₃ in an amount of 5 to 23 wt%, Li₂O in an amount of 3 to 10 wt%, and
Na₂O in an amount of 4 to 13 wt% was used as this aluminosilicate glass. Note
that the content of Al₂O₃ is 8.5 mol%. Hereinafter, this glass material is referred to
as "Glass Material 1".

[0063]

15 Next, in order to improve dimensional accuracy and shape accuracy, the
rough grinding processing was performed on this glass substrate using
alumina-based loose abrasive particles. This rough grinding processing was
performed using a double-side grinding apparatus.

[0064]

20 (2) Shape processing

Next, a cylindrical grindstone was used to create a hole in the central
portion of the glass substrate and an outer circumferential edge surface was
ground to have a diameter of 65 mmφ, whereafter predetermined chamfering was
performed on the outer circumferential edge surface and an inner circumferential
25 edge surface. In general, a magnetic disk having an outer diameter of 65 mm is
used in a 2.5-inch HDD (hard disk drive).

[0065]

(3) Precision grinding processing

This precision grinding processing was performed using a double-side grinding apparatus in which the glass substrate held by a carrier was tightly placed between the upper and lower surface plates to which pellets obtained by fixing diamond abrasive particles with a resin were attached, while a coolant was supplied. A roughness Ra of main surfaces of the substrate after the precision grinding processing was 100 nm or less. Note that the surface roughness after the precision grinding processing was measured using a stylus type roughness tester.

After undergoing the above-described precision grinding processing, the glass substrate was cleaned.

[0066]

(4) Edge surface polishing processing

Next, the edge surfaces (inner and outer circumferential edge surfaces) of the glass substrate were polished through brushing while the glass substrate was rotated. A roughness Ra of main surfaces of the substrate after the edge surface polishing processing was 100 nm or less. Then, after undergoing edge surface polishing above, the glass substrate was cleaned.

[0067]

(5) Main surface first polishing processing

Next, the first polishing processing for removing blemishes and warping remaining from the above-described grinding processing so as to achieve predetermined smooth surfaces was performed using the above-described double-side polishing apparatus shown in FIG 3. above. In the double-side polishing apparatus, the glass substrate that is held by the carrier 4 is tightly placed between the upper and lower surface plates 5 and 6 to which the polishing pads 7 have been attached, the carrier 4 is engaged with the sun gear 2 and the internal gear 3, and the glass substrate is pressed by the upper and lower surface plates 5 and 6. Thereafter, a polishing liquid is supplied between the polishing pads and

the glass substrate surfaces to be polished, the gears and the upper and lower surface plates are rotated, and thereby the glass substrate revolves while rotating on the surface plates 5 and 6 so that both surfaces of the glass substrate are polished simultaneously due to the planetary gear mechanism. Specifically, the first polishing processing was performed using a suede polisher (made of polyurethane foam) having an Asker C hardness of 80, as the polisher (polishing pad).

[0068]

An alkaline polishing liquid that contained 10 wt% cerium oxide (having an average particle diameter of 1 μm) as polishing abrasive particles and 5 wt% sodium thiosulfate as the inorganic reducing agent, and had a pH of 10 was used as the polishing liquid. Also, the polishing load was set to 120 g/cm^2 and the machining allowance was set to 30 μm in terms of the substrate thickness. A roughness R_a of the surfaces of the substrate after polishing was 1.5 nm or less.

In the above-described first polishing processing, 20 batches (100 substrates per batch) were continuously processed without replacing the polishing liquid. After undergoing the above-described first polishing processing, the glass substrates were cleaned.

[0069]

(6) Chemical strengthening processing

Next, chemical strengthening was performed on the glass substrates that had undergone the above-described cleaning. Chemical strengthening processing was performed by immersing the glass substrates that were cleaned and dried, in a chemical strengthening liquid, which was a molten salt obtained by mixing and melting potassium nitrate and sodium nitrate. After undergoing chemical strengthening, the glass substrates were cleaned.

[0070]

(7) Main surface second polishing processing

Next, the second polishing processing was performed using the same double-side polishing apparatus as used in the above-described first polishing processing, but polishing pads (made of polyurethane foam) with a soft polisher (suede type) having an Asker C hardness of 70 as the polisher were used instead.

5 This second polishing processing is mirror-polishing processing for finishing the main surfaces of the glass substrates into smooth mirror surfaces, for example, such that the surface roughness Ra of the main surfaces of the glass substrates is 0.2 nm or less and a surface roughness Rmax thereof is 2 nm or less. A polishing liquid containing 10 wt% colloidal silica (having an average particle diameter of 15
10 nm) as polishing abrasive particles was used as the polishing liquid. Note that the pH of the polishing liquid was adjusted to be acidic (pH=2) by adding sulfuric acid to the polishing liquid in advance. Also, the polishing load was set to 100 g/cm² and the machining allowance was set to 3 μm in terms of the substrate thickness.

[0071]

15 Next, after undergoing the above-described second polishing processing, the glass substrates were subjected to cleaning processing (final cleaning processing). Specifically, ultrasound cleaning was performed by immersing the glass substrates into a cleaning tank in which an alkaline detergent was added to pure water. Thereafter, the glass substrates were sufficiently rinsed with pure
20 water and then dried.

[0072]

When the surface roughness (Ra) of the main surfaces of the glass substrates that were obtained through the above-described processes and after the above-described final cleaning processing was measured using an atomic force
25 microscope (AFM), the glass substrates with smooth surfaces having an Ra of 0.2 nm or less and an Rmax of 2 nm or less were obtained.

[0073]

(Working Examples 2 to 4)

Glass substrates of Working Examples 2 to 4 were produced similarly to Working Example 1 except that polishing liquids obtained by respectively substituting the inorganic reducing agent included in the polishing liquid that was used in the main surface first polishing processing in Working Example 1 above with sodium phosphinate, sodium dithionite, and sodium sulfite were used.

[0074]

(Comparative Example 1)

A glass substrate of Comparative Example 1 was produced similarly to Working Example 1 except that a polishing liquid that did not contain an inorganic reducing agent was used as the polishing liquid that was used in the main surface first polishing processing in Working Example 1 above.

[0075]

The polishing speeds in the above-described main surface first polishing processing of Working Examples 1 to 4 and Comparative Example 1 above were measured in the first batch and the tenth batch, the increase ratios of the polishing speeds of the working examples with respect to the polishing speed of Comparative Example 1 were determined with the following standards, and the results are collectively shown in Table 1 below. Here, in Comparative Example 1, when the ratio of the polishing speed of the tenth batch to the first batch (polishing speed of tenth batch/polishing speed of first batch) was calculated, the ratio was 0.9.

Note that when a glass substrate was produced similarly to Working Example 1 except that the inorganic reducing agent in Working Example 1 was changed to ascorbic acid, which is an organic reducing agent, the polishing speeds in the first batch and the tenth batch were equivalent to that of Comparative Example 1.

[Determination Standards]

With respect to the polishing speed of the comparative example in the

same batch,

●	(Level 5)	greater than 115%
◎	(Level 4)	greater than 110% and 115% or less
○	(Level 3)	greater than 105% and 110% or less
△	(Level 2)	greater than 100% and 105% or less
×	(Level 1)	100% or less

[0076]

[Table 1]

Table 1	Comparative Example 1	Working Example 1	Working Example 2	Working Example 3	Working Example 4
	no additive	Na thiosulfate	Na phosphinate	Na dithionite	Na sulfite
Polishing speed in 1st batch	Ref.	○	△	△	△
Polishing speed in 10th batch	Ref.	○	△	△	△

5

[0077]

Based on the results of Table 1 above, the following was found.

1. According to the working examples of the present invention, by adding the inorganic reducing agent of the present invention to the polishing liquid containing cerium oxide abrasive particles under the alkaline condition, the polishing speed can be improved with respect to the comparative example that does not contain the inorganic reducing agent.

Also, among inorganic reducing agents, in particular, thiosulfates are preferable because they have a better polishing speed increase effect.

2. Also, according to the working examples of the present invention, it is found that such a trend continues not only in the first batch but also in the tenth batch, and even in the case where many substrates are subjected to the polishing processing through continuous polishing processing, the effect of increasing the polishing speed caused by addition of a reducing agent is long-lasting. Therefore,

15

it is possible to effectively suppress a decrease in the polishing speed during continuous polishing processing.

[0078]

(Working Examples 5 to 8)

5 Glass substrates of Working Examples 5 to 8 were produced similarly to Working Examples 1 to 4 except that a polishing liquid was used which was obtained by substituting the polishing abrasive particles that were included in the polishing liquids that were used in the main surface first polishing processing in Working Examples 1 to 4 above, with cerium oxide abrasive particles containing
10 20% La as the ratio of La_2O_3 to TREO.

[0079]

(Comparative Example 2)

 A glass substrate of Comparative Example 2 was produced similarly to Comparative Example 1 except that a polishing liquid was used which was
15 obtained by substituting the polishing abrasive particles that were included in the polishing liquid that was used in the main surface first polishing processing in Comparative Example 1 above, with cerium oxide abrasive particles containing 20% La as the ratio of La_2O_3 to TREO.

[0080]

20 The polishing speeds of Working Examples 5 to 8 and Comparative Example 2 above in the above-described main surface first polishing processing were measured in the first batch and the tenth batch, increase ratios of the polishing speeds in the working examples with respect to the polishing speed of Comparative Example 2 were determined with the same determination standards
25 as above, and the results are collectively shown in Table 2 below. Here, in Comparative Example 2, when the ratio of the polishing speed of the tenth batch to the first batch (polishing speed of tenth batch/polishing speed of first batch) was calculated, the ratio was 0.9.

Note that when a glass substrate was produced similarly to Working Example 5 except that the inorganic reducing agent in Working Example 5 was changed to ascorbic acid, which is an organic reducing agent, the polishing speeds in the first batch and the tenth batch were equivalent to that of Comparative

5 Example 2.

[0081]

[Table 2]

Table 2	Comparative Example 2	Working Example 5	Working Example 6	Working Example 7	Working Example 8
	no additive	Na thiosulfate	Na phosphinate	Na dithionite	Na sulfite
Polishing speed in 1st batch	Ref.	◎	○	○	○
Polishing speed in 10th batch	Ref.	◎	○	○	○

[0082]

10 Based on the results of Table 2 above, the following was found.

1. Even in the case where the cerium oxide abrasive particles to which La was added is used, the polishing speed can be improved with respect to the comparative example that does not contain an inorganic reducing agent by adding the inorganic reducing agent of the present invention to the polishing liquid.

15 Also, among inorganic reducing agents, in particular, thiosulfates are preferable because they have a better polishing speed increase effect. Moreover, based on the comparison with the results of Table 1 above, it is found that the polishing speed increase ratio increases due to use of the cerium oxide abrasive particles to which La is added.

20 2. Also, according to the working examples of the present invention, such a trend continues not only in the first batch but also in the tenth batch, and it is possible to effectively suppress a decrease in the polishing speed during the continuous polishing processing. In particular, thiosulfates achieve, in the tenth

batch as well, a polishing speed that is equivalent to or better than that in the first batch of Comparative Example 2 and thus exhibit a significantly better effect.

[0083]

(Working Example A)

5 Similarly to Working Example 1 above, (1) rough grinding processing, (2) shape processing, (3) precision grinding processing, (4) edge surface polishing processing, and (5) main surface first polishing processing were performed sequentially.

10 However, a glass substrate in which the content of Al_2O_3 in Glass Material 1 above was 10 mol% was used. This glass material is referred to as "glass material A".

[0084]

15 Also, an alkaline polishing liquid that contained cerium oxide (having an average particle diameter of 1 μm) containing 20% La as the ratio of La_2O_3 to TREO as the polishing abrasive particles (the content was 10 wt%), contained 5 wt% sodium thiosulfate as the inorganic reducing agent, and had a pH of 10 was used as the polishing liquid in the above-described main surface first polishing processing. The other polishing processing conditions were the same as those of Working Example 1.

20 [0085]

(Working Example B)

Processing that was similar to that of Working Example A above was performed except that Glass Material B was used instead of Glass Material A that was used in Working Example A above.

25 Glass Material B Heat resistant glass that contains SiO_2 in an amount of 50 to 75 mol%, Al_2O_3 in an amount of 0 to 6 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.

5 [0086]

The polishing speeds of Working Examples A and B above in the above-described main surface first polishing processing were measured in the first batch and the twentieth batch, a ratio of the polishing speed in the twentieth batch where the polishing speed in the first batch was 1 was found, and the results are collectively shown in Table 3 below.

10

[0087]

[Table 3]

Table 3	Glass Material	1st batch	20th batch
Working Example A	Glass Material A	1.00	0.60
Working Example B	Glass Material B	1.00	0.81

[0088]

As can be understood from the results of Table 3 above, in particular, the present invention is suitable for processing for polishing a heat resistant glass substrate (Glass Material B) having a high glass transition temperature (T_g). By performing the polishing processing to which the polishing liquid containing the cerium oxide abrasive particles and the inorganic reducing agent of the present invention is applied, the effect of suppressing a decrease in the polishing speed especially during continuous polishing processing is greater than in the case where the aluminosilicate glass (Glass Material A) above is used, for example.

15

20

[0089]

(Working Examples 9 to 12 and Comparative Example 3)

Similarly to Working Example 1 above, (1) rough grinding processing, (2) shape processing, and (3) precision grinding processing were performed

25

sequentially, and then edge surface polishing processing below was performed.
Note that Glass Material 1 above was used as the glass substrate.

The glass substrates resulting from the grinding processing above were stacked using a support jig to form a glass substrate stacked body. At that time,
5 the glass substrate stacked body was formed by inserting resin spacers between glass substrates and placing 200 glass plates in total on one another.

[0090]

The glass substrate stacked body formed in the above manner was inserted into a jig for outer circumferential edge surface polishing and the glass
10 substrate stacked body was fixed by clamping the glass substrate stacked body vertically. That glass substrate stacked body was installed at a predetermined position of the outer circumferential edge surface polishing apparatus. The rotary brush for edge surface polishing was brought into contact with and pressed against the outer circumferential side edge surface of the glass substrate stacked body by
15 a predetermined amount.

The polishing liquid was supplied to an outer circumferential edge surface portion of the glass substrate stacked body, the rotary brush and the glass substrate stacked body were rotated in the opposite directions, and the glass substrate stacked body was polished while the rotary brush was swung in the
20 direction in which the glass substrates were stacked.

[0091]

The same polishing liquid as that used in Working Examples 5 to 8 and Comparative Example 2 (that is, an alkaline polishing liquid that contained cerium oxide (having an average particle diameter of 1 μm) containing 20% La as the ratio
25 of La_2O_3 to TREO as the polishing abrasive particles (the content was 10 wt%), contained 5 wt% inorganic reducing agents shown in Table 4, and had a pH of 10) was used as the polishing liquid.

[0092]

Note that in these working examples and comparative example, the polishing liquid supply amount was set to 10 to 15 L/min, the rotation speed of the rotary brush was set to 300 rpm, the swing speed of the rotary brush in the support axial direction was set to 3 to 5 rpm (3 to 5 reciprocations per minute), and the rotation speed of the glass substrate stacked body was set to 80 to 90 rpm. The machining allowance was 40 μm in terms of the substrate thickness.

Note that the polishing liquid was not replaced in the working examples and the comparative example, and 20 batches were continuously processed while the polishing liquid was collected and the collected polishing liquid was circulated.

10 [0093]

The polishing speeds of the Working Examples 9 to 12 and Comparative Example 3 in the above-described edge surface polishing processing were measured in the first batch and the tenth batch, polishing speed increase ratios of each working example with respect to the polishing speed of Comparative Example 3 in which the polishing liquid that did not contain the inorganic reducing agent was used were determined using the same determination standards as the above, and the results are collectively shown in Table 4 below. Here, in Comparative Example 3, when the ratio of the polishing speed of the tenth batch to the first batch (polishing speed of tenth batch/polishing speed of first batch) was calculated, the ratio was 0.80.

[0094]

[Table 4]

Table 4	Comparative Example 3	Working Example 9	Working Example 10	Working Example 11	Working Example 12
	no additive	Na thiosulfate	Na phosphinate	Na dithionite	Na sulfite
Polishing speed in 1st batch	Ref.	⊙	○	○	○
Polishing speed in 10th batch	Ref.	●	⊙	⊙	⊙

[0095]

Based on the results of Table 4 above, the following was found.

In the processing for polishing edge surfaces of glass substrates as well, by adding the inorganic reducing agent of the present invention to the polishing liquid, the polishing speed can be improved with respect to the comparative example that
5 did not contain the inorganic reducing agent.

Also, among inorganic reducing agents, in particular, thiosulfates are preferable because they have a better polishing speed increase effect. Also, according to the working examples of the present invention, such a trend continues not only in the first batch but also in the tenth batch, and it is possible to effectively
10 suppress a decrease in the polishing speed during continuous polishing processing. Moreover, in the tenth batch, the polishing speed of the comparative example decreases significantly, and thus the effect of the inorganic reducing agent increases relatively and the polishing speed increase ratio became higher than in the first batch. The polishing speed of the edge surface polishing processing is
15 more likely to decrease than that of the main surface polishing processing, and thus, in particular, the present invention is effective.

[0096]

(Working Examples 13 to 16)

Glass substrates of Working Examples 13 to 16 were produced similarly to
20 Working Example 5 except that a polishing liquid was used which was obtained by respectively changing the pH of the polishing liquid that was used in Working Example 5 (the alkaline polishing liquid that contained cerium oxide (having an average particle diameter of 1 μm) containing 20% La as the ratio of La_2O_3 to TREO as the polishing abrasive particles, contained 5 wt% of sodium thiosulfate as
25 the inorganic reducing agent, and had a pH of 10) to 8, 9, 11, and 12.

[0097]

The polishing speeds of Working Examples 13 to 16 above and Working Example 5 above in the above-described main surface first polishing processing

were measured in the twentieth batch, the ratios of the polishing speeds of each working example where the polishing speed with the pH of 10 (Working Example 5) was 1 were found, and the results are collectively shown in Table 5 below.

[0098]

5 [Table 5]

Table 5	pH	Polishing speed ratio in 20th batch
Working Example 13	8	0.95
Working Example 14	9	0.98
Working Example 5	10	1.00 (reference)
Working Example 15	11	0.97
Working Example 16	12	0.93

[0099]

Based on the results of Table 5 above, in the present invention, the pH of the polishing liquid is particularly preferably in a range of 9 to 11. It is inferred that decomposition of the inorganic reducing agent is favorably suppressed in this pH range.

10

[0100]

(Manufacture of magnetic disk)

A magnetic disk for perpendicular magnetic recording was obtained by performing the following film formation steps on the magnetic-disk glass substrate that was obtained in Working Example 1 above.

15

That is, an adherent layer constituted by a CrTi-based alloy thin film, a soft magnetic layer constituted by a CoTaZr alloy thin film, a seed layer constituted by NiW, a base layer constituted by a Ru thin film, a perpendicular magnetic recording layer made of a CoCrPt-based alloy, a carbon protective layer, and a lubricant layer were sequentially formed on the above-described 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 using a dipping method using an alcohol-modified perfluoropolyether liquid

20

lubricant.

[0101]

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 and a good result was obtained. Note that similar results were obtained also in the case where the magnetic-disk glass substrates that were obtained in the other working examples were used.

10

Descriptions of Reference Numerals

[0102] 1 Glass substrate

2 Sun gear

3 Internal gear

15 4 Carrier

5 Upper surface plate

6 Lower surface plate

7 Polishing pad

11 Main surface of substrate

20 12, 13 Edge surface of substrate

CLAIMS

1. A method for polishing a glass substrate, by which a surface of a glass substrate is subjected to polishing processing using a polishing liquid containing cerium oxide as polishing abrasive particles,
5 wherein the polishing liquid is alkaline and contains an inorganic reducing agent.
2. The method for polishing a glass substrate according to claim 1,
 wherein the inorganic reducing agent is at least one selected from thiosulfates, phosphinates, dithionites, and sulfites with alkali metals or alkaline
10 earth metals.
3. The method for polishing a glass substrate according to claim 1 or 2,
 wherein a pH of the polishing liquid is in a range of 8 to 12.
4. The method for polishing a glass substrate according to any of claims 1
 to 3,
15 wherein the cerium oxide abrasive particles contain lanthanum (La).
5. A method for manufacturing a glass substrate, comprising:
 polishing processing to which the method for polishing a glass substrate
 according to any of claims 1 to 4 is applied.
6. A method for manufacturing a magnetic-disk glass substrate, to which
20 the method for manufacturing a glass substrate according to claim 5 is applied,
 wherein the glass substrate is a magnetic-disk glass substrate.
7. A method for manufacturing a magnetic disk,
 wherein at least a magnetic film is formed on a magnetic-disk glass
 substrate manufactured using the method for manufacturing a magnetic-disk glass
25 substrate according to claim 6.
8. A polishing liquid that is to be used in processing for polishing a surface
 of a glass substrate,

wherein the polishing liquid is alkaline, contains cerium oxide as polishing abrasive particles, and further contains an inorganic reducing agent.