

DESCRIPTION

Title of Invention:

METHOD FOR MANUFACTURING GLASS SUBSTRATE FOR MAGNETIC DISK,
5 METHOD FOR MANUFACTURING MAGNETIC DISK, AND CLEANING LIQUID
FOR CLEANING GLASS SUBSTRATE FOR MAGNETIC DISK

Technical Field

[0001]

10 The present invention relates to a method for manufacturing a magnetic
disk glass substrate that is mounted on a magnetic disk device such as a hard disk
drive (HDD), a method for manufacturing a magnetic disk, and a cleaning liquid for
cleaning a magnetic disk glass substrate.

15 Background Art

[0002]

A magnetic disk is one of the information recording media mounted on
magnetic disk drives such as hard disk drives (HDDs). The magnetic disk is
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 space between the magnetic head and the magnetic disk can be made
narrower than that attained with aluminum substrates have been increasingly used.
The glass substrate surface is highly precisely polished to achieve a high
25 recording density such that the flying height of the magnetic head can be reduced
to as low as possible. In recent years, the demand for HDDs with a larger
storage capacity has been increasing, and in order to meet this, further quality
improvement is required for magnetic disk glass substrates, or in other words,
magnetic disk glass substrates are required to have a smoother and cleaner glass

substrate surface.

[0003]

As stated above, it is essential for a magnetic disk to have a highly smooth surface to achieve a low flying height that is necessary for achieving a high recording density. In order to attain a highly smooth magnetic disk surface, after all, a highly smooth substrate surface is required, and it is thus necessary to highly precisely polish the surface of a glass substrate. However, this is not sufficient, and it is also necessary to perform cleaning after polishing so as to remove extraneous matter adhering to the substrate surface to obtain a clean substrate surface.

As conventional methods, for example, Patent Document 1 discloses a method in which a substrate is polished by using a polishing liquid containing a multivalent amine and thereafter subjected to alkaline cleaning (with a pH of 8 to 13). Patent Document 2 discloses a method for cleaning a polished substrate by using an alkaline cleaning agent having a pH of 10 or more and containing an alkaline agent and an aldonic acid.

Prior Art Document

Patent Document

[0004]

Patent Document 1: JP 2012-107226A

Patent Document 2: JP 2010-86563A

Summary of Invention

Problem to be Solved by the Invention

[0005]

Currently available HDDs can achieve a recording density as high as about 500 gigabits per square inch, and for example, it is possible to store about 320 gigabytes of information on a 2.5-inch (65-mm-diameter) magnetic disk.

However, HDDs are required to achieve a further higher recording density, such as 375 to 500 gigabytes and even a terabyte. With the recent trend toward increasing demand for HDDs with a larger storage capacity, the need for improvement in the substrate surface quality is greater than ever.

- 5 Next-generation substrates for magnetic disks of, for example, 375 to 500 gigabytes as described above can have a great influence on the media characteristics, and thus a further improvement from the currently available HDDs is required, not only in terms of the surface roughness of substrates, but also with regard to the absence of surface defects caused by extraneous matter adhering to
- 10 the substrate surface or the like.

[0006]

The reason that next-generation substrates have a great influence on the media characteristics is explained as follows.

- A significant reduction is achieved in the amount of flying height of the
- 15 magnetic head (the gap between the magnetic head and the surface of media (magnetic disk)) (lower amount of flying height). This reduces the distance between the magnetic head and the magnetic layer of the media, which makes it possible to pick up even the signals of smaller magnetic particles, and hence achieving a high recording density. In recent years, in order to achieve a lower
- 20 amount of flying height than ever before, magnetic heads are equipped with a function called DFH (Dynamic Flying Height). This function is to cause only the tip of the recording/reproducing element of a magnetic head to protrude toward the media surface by providing a heating unit such as a very small heater at the tip of the recording/reproducing element. In the future, it is expected that the DFH
- 25 function will reduce the gap between the recording/reproducing element of a magnetic head and the media surface to an extremely low level such as less than 2 nm or less than 1 nm. Under the circumstances, even if the average surface roughness of the substrate is reduced to an extremely low level, if there is a surface defect such as a miniscule protrusion, which was considered to be no

problem in the conventional technology, formed by very small extraneous matter (for example, with a length in an in-plane direction of the main surface of about 10 to 40 nm at minimum) adhering to the substrate surface, the risk of collision of the magnetic head increases because the protrusion remains on the media surface as a defect.

[0007]

Investigations conducted by the present inventors have revealed that it is not possible to achieve both a low surface roughness and a high level of cleanliness in the substrate after cleaning by using various conventional precision polishing techniques and precision cleaning techniques including the techniques disclosed in the patent literatures mentioned above, or even by simply combining these techniques.

The need for improvement in the substrate surface quality associated with the recent demand for HDDs with a larger storage capacity is greater than ever, and there is a limit to achieving a further improvement in the substrate surface quality by using conventional improvement methods.

[0008]

The present invention has been made to solve the problems encountered with the conventional techniques, and a first object of the present invention is to provide a method for manufacturing a glass substrate for a magnetic disk in which cleaning processing can be performed without compromising a smooth surface roughness obtained through precision polishing as much as possible, and as a result, a low surface roughness (a high level of smoothness) can be achieved. A second object is to provide a cleaning liquid that is suitable for use in the cleaning processing. A third object is to provide a method for manufacturing a glass substrate for a magnetic disk in which cleaning that provides a high level of cleanliness can be carried out.

Means for Solving the Problem

[0009]

In order to increase the level of cleanliness of the substrate, it is necessary to remove extraneous matter that has firmly adhered to the substrate surface by cleaning. For this reason, it is preferable to perform cleaning by using an alkaline solution with high alkalinity because a high level of cleanliness can be achieved. The reason is that the glass surface is etched by the alkaline solution with high alkalinity, and thus even the extraneous matter firmly adhering to the surface can be completely removed. However, with the conventional alkaline cleaning, the etching effect with respect to glass increases as the alkalinity increases.

Accordingly, the surface roughness of the substrate increases due to the alkaline cleaning, and it is therefore not possible to maintain an ultra-smooth surface roughness obtained through precision polishing. To address this, the present inventors conducted investigations for a method for suppressing the increase in the surface roughness of the substrate while maintaining the cleaning power obtained by alkaline cleaning in the case where a large number of glass substrates are sequentially cleaned for a long period of time. As a result, the present inventors found that the concentration of alkali metal ions such as sodium ions and potassium ions contained in the cleaning liquid is responsible for the increase in the surface roughness of the glass substrate.

The present inventors also found that, not only the alkalinity of the alkaline agent used in cleaning, but also the type of positive ions that pair with OH ions also significantly affects the increase in the surface roughness.

[0010]

The present inventors have accomplished the present invention based on the above findings and the results of their intensive study.

To be specific, the present invention has the following aspects.

(Aspect 1)

A method for manufacturing a glass substrate for a magnetic disk including glass substrate cleaning processing, wherein the glass substrate contains at least

one component of sodium and potassium in a glass component; and cleaning processing is performed on a plurality of the glass substrates having a main surface polished into a mirror-finished surface by using a cleaning liquid containing an alkaline agent that is free of sodium and potassium, and maintaining a
5 condition in which a total concentration of sodium ions and potassium ions in the cleaning liquid is 4.00×10^{-3} mol/L or less.

[0011]

(Aspect 2)

The method for manufacturing a glass substrate for a magnetic disk
10 according to aspect 1, wherein the mirror-finished surface refers to the main surface of the glass substrate having a surface roughness Ra of 0.15 nm or less.

(Aspect 3)

The method for manufacturing a glass substrate for a magnetic disk according to aspect 1 or 2, wherein a difference between the surface roughness
15 (Ra) of the main surface of the glass substrate after being subjected to the cleaning processing and the surface roughness (Ra) of the main surface of the glass substrate immediately before being subjected to the cleaning processing is within 0.06 nm.

[0012]

20 (Aspect 4)

The method for manufacturing a glass substrate for a magnetic disk according to any one of aspects 1 to 3, wherein a total concentration of sodium ions and potassium ions in the cleaning liquid is 2.00×10^{-3} mol/L or less.

(Aspect 5)

25 The method for manufacturing a glass substrate for a magnetic disk according to any one of aspects 1 to 4, wherein the alkaline agent is tetraalkyl ammonium hydroxide.

[0013]

(Aspect 6)

The method for manufacturing a glass substrate for a magnetic disk according to any one of aspects 1 to 5, wherein the cleaning liquid further contains a surfactant that is free of sodium and potassium.

(Aspect 7)

- 5 The method for manufacturing a glass substrate for a magnetic disk according to any one of aspects 1 to 6, wherein glass constituting the glass substrate is aluminosilicate glass containing at least one of Na_2O and K_2O .

[0014]

(Aspect 8)

- 10 A method for manufacturing a glass substrate for a magnetic disk including glass substrate cleaning processing, wherein a relationship between an amount of increase in surface roughness (Ra) of a main surface of the glass substrate after being subjected to the cleaning processing with respect to that before being subjected to the cleaning processing and a total concentration of sodium ions and
15 potassium ions in a cleaning liquid used in the cleaning processing is obtained in advance, the total concentration of sodium ions and potassium ions in the cleaning liquid is determined based on the obtained relationship such that the amount of increase in the surface roughness (Ra) is 0.06 nm or less, and the cleaning processing is performed on the glass substrate having a main surface polished
20 into a mirror-finished surface by maintaining a condition in which the total concentration of sodium ions and potassium ions in the cleaning liquid is less than or equal to the determined concentration.

(Aspect 9)

- 25 A method for manufacturing a glass substrate for a magnetic disk including glass substrate cleaning processing, wherein the glass substrate contains at least one component of sodium and potassium in a glass component, and cleaning processing is performed on the glass substrate having a main surface polished into a mirror-finished surface by using a cleaning liquid containing an alkaline agent that is free of sodium and potassium, and performing replacement of the

cleaning liquid if a total concentration of sodium ions and potassium ions in the cleaning liquid exceeds 4.00×10^{-3} mol/L.

[0015]

(Aspect 10)

- 5 A method for manufacturing a glass substrate for a magnetic disk including glass substrate cleaning processing, wherein the cleaning processing includes processing of bringing the glass substrate into contact with a cleaning liquid containing tetramethyl ammonium ions, and the cleaning processing is performed while suppressing a total amount of sodium ions and potassium ions in the
- 10 cleaning liquid to less than 200 ppm.

(Aspect 11)

- A method for manufacturing a glass substrate for a magnetic disk including glass substrate cleaning processing, wherein the cleaning processing includes processing of bringing the glass substrate into contact with a cleaning
- 15 liquid having etchability with respect to the glass substrate and containing tetramethyl ammonium ions.

[0016]

(Aspect 12)

- The method for manufacturing a glass substrate for a magnetic disk
- 20 according to aspect 11, wherein the cleaning processing is performed while suppressing a total amount of sodium ions and potassium ions in the cleaning liquid to less than 200 ppm.

(Aspect 13)

- The method for manufacturing a glass substrate for a magnetic disk
- 25 according to any one of aspects 10 to 12, wherein the glass substrate contains at least one component of sodium and potassium in a glass component.

[0017]

(Aspect 14)

 The method for manufacturing a glass substrate for a magnetic disk

according to any one of aspects 10 to 13, wherein the cleaning liquid further contains at least one substance of a surfactant, a chelating agent and a dispersing agent, and the cleaning processing is performed while suppressing the total amount of sodium ions and potassium ions in the cleaning liquid to less than 200 ppm.

(Aspect 15)

The method for manufacturing a glass substrate for a magnetic disk according to any one of aspects 10 to 14, wherein a difference between surface roughness (Ra) of a main surface of the glass substrate after being subjected to the cleaning processing and the surface roughness (Ra) of the main surface of the glass substrate immediately before being subjected to the cleaning processing is within 0.06 nm.

[0018]

(Aspect 16)

The method for manufacturing a glass substrate for a magnetic disk according to any one of aspects 10 to 15, wherein the surface roughness (Ra) of the main surface of the glass substrate immediately before being subjected to the cleaning processing is 0.13 nm or less.

(Aspect 17)

The method for manufacturing a glass substrate for a magnetic disk according to any one of aspects 10 to 16, wherein the cleaning liquid has a pH of 10 or more.

[0019]

(Aspect 18)

The method for manufacturing a glass substrate for a magnetic disk according to any one of aspects 10 to 17, wherein the cleaning processing is cleaning processing that is performed after a final polishing step among polishing steps of polishing the main surface of the glass substrate by using polishing abrasive grains.

(Aspect 19)

A cleaning liquid for cleaning a glass substrate for a magnetic disk, which is used in cleaning processing for cleaning the glass substrate for a magnetic disk, wherein the cleaning liquid contains at least tetramethyl ammonium hydroxide and
5 a surfactant that is free of sodium and potassium.

(Aspect 20)

A method for manufacturing a magnetic disk, including forming at least a magnetic recording layer on the glass substrate for a magnetic disk obtained by the method for manufacturing a glass substrate for a magnetic disk according to
10 any one of aspects 1 to 18.

Advantageous Effects of the Invention

[0020]

According to the present invention, it is possible to provide a method for
15 manufacturing a glass substrate for a magnetic disk in which cleaning processing can be carried out without compromising a smooth surface roughness obtained through precision polishing as much as possible, and as a result, a low surface roughness (a high level of smoothness) can be achieved. Also, according to the present invention, it is possible to provide a method for manufacturing a glass
20 substrate for a magnetic disk in which cleaning that provides a high level of cleanliness can be carried out. According to the present invention as described above, it is possible to manufacture, at low cost, high-quality magnetic disk glass substrates that achieve a further reduction in the surface roughness of the main surface of the substrates and a reduction of surface defects caused by extraneous
25 matter adhering to the substrate surface or the like as compared to conventional substrates. Also, according to the present invention, it is possible to provide a cleaning liquid suitable for use in the cleaning processing.

The magnetic disk glass substrate obtained by the present invention is suitable for use as, in particular, a next-generation substrate required to meet

more strict substrate surface quality requirements than the currently available substrates. In addition, with the use of the glass substrate obtained by the present invention, it is possible to obtain a highly reliable magnetic disk that can perform a stable operation for a long time even when combined with a magnetic head equipped with the DFH function and designed to have a very low amount of flying height.

Brief Description of Drawings

[0021]

- 10 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 vertical cross-sectional view showing a schematic configuration of a double-side polishing machine.

15 Mode for Embodying the Invention

[0022]

Hereinafter, embodiments of the present invention will be described.

(First Embodiment)

- A magnetic disk glass substrate is usually manufactured through rough
20 grinding processing, shaping processing, precision grinding processing, end face polishing processing, main surface polishing processing (first polishing processing and second polishing processing), and chemical strengthening processing.

[0023]

- In the manufacturing of the magnetic disk glass substrate, first, molten
25 glass is molded into a disk-shaped glass substrate (glass disk) by direct pressing. Other than using such direct pressing, a glass substrate (glass disk) may also be obtained by cutting plate glass that has been produced by a downdraw method or a float method into a glass substrate with a predetermined size. Then, this molded glass substrate (glass disk) is ground to improve the dimensional accuracy

and shape accuracy. In this grinding processing, usually, a double-side grinding machine is used, and the main surfaces of the glass substrate are ground using hard abrasive grains such as those of diamond. By grinding the main surfaces of the glass substrate in this manner, the substrate is processed so as to have a predetermined thickness and flatness and attain a predetermined surface roughness.

[0024]

After the grinding processing, polishing processing for obtaining a highly precise flat surface (mirror-finished surface) is performed. A preferable method for polishing a glass substrate is to perform polishing by using a polishing pad made of, for example, polyurethane while supplying a slurry (polishing liquid) containing a polishing material made of, for example, a metal oxide such as cerium oxide or colloidal silica.

[0025]

Polishing liquids used in conventional polishing processing are basically made of a combination of a polishing material and water as a solvent, and optionally contain a pH adjusting agent for adjusting the pH of the polishing liquid, and other additives.

[0026]

A polishing liquid containing colloidal silica abrasive grains and the like can be composed by using, for example, water or pure water, and adding necessary additives.

[0027]

The polishing liquid used in the polishing processing (in particular, final polishing processing (second polishing processing, which will be described later)) is preferably adjusted to have, for example, an acid pH. For example, the pH is adjusted to be within a range of 2 to 4 by adding sulfuric acid to the polishing liquid. In the present invention, the reason that the polishing liquid is preferably adjusted to have an acid pH is the consideration of productivity and cleanliness.

[0028]

From the viewpoint of polishing efficiency, it is preferable that the polishing abrasive grains, such as colloidal silica, contained in the polishing liquid have an average particle size of 100 nm or less. In particular, in the present invention, as
5 the polishing abrasive grains contained in the polishing liquid for use in the final polishing processing (second polishing processing, which will be described later), it is preferable to use polishing abrasive grains having an average particle size of 40 nm or less, and more particularly it is preferable to use fine polishing abrasive grains having an average particle size of 20 nm or less from the viewpoint of
10 achieving a further reduction in the surface roughness. If the average particle size is less than 10 nm, the polishing efficiency may be compromised.

In the present invention, the average particle size refers to the 50% particle size of an accumulation curve obtained by setting the total volume of a mass of powders in a particle size distribution measured by a light scattering
15 method to 100% (hereinafter, referred to as "accumulation average particle size (50% diameter)"). In the present invention, the accumulation average particle size (50% diameter) is a value obtained through measurement by using, for example, a particle size/particle size distribution measuring apparatus.

[0029]

20 As the colloidal silica abrasive grains used in the present invention, it is possible to use colloidal silica abrasive grains produced by hydrolysis of an organosilicon compound. Such abrasive grains are fine abrasive grains having a uniform particle size because the abrasive grains hardly aggregate to each other. However, they are likely to strongly adhere to the glass substrate surface that has
25 undergone polishing processing. It is therefore effective to use the cleaning processing of the present invention.

As another method for producing colloidal silica, a water glass method can be used. The water glass method is a method in which soda silicate is ion-exchanged so as to prepare active silica, which is then added to an aqueous

solution containing seed particles whose pH has been adjusted with the use of NaOH under heat, so as to grow particles. According to this method, it is possible to obtain particles having a relatively dense structure.

[0030]

5 In the present invention, there is no particular limitation on the polishing method performed in the polishing processing, but it is possible to, for example, bring the glass substrate into contact with a polishing pad, move the polishing pad and the glass substrate relative to each other while supplying a polishing liquid containing polishing abrasive grains, and thereby polish the surface of the glass
10 substrate into a mirror-finished surface.

For example, FIG. 3 is a vertical cross-sectional view showing a schematic configuration of a planetary gear type double-side polishing machine that can be used in the glass substrate polishing processing. The double-side polishing machine shown in FIG. 3 includes a sun gear 2, an internal gear 3 externally
15 concentrically disposed with respect to the sun gear 2, a carrier 4 that is engaged with the sun gear 2 and the internal gear 3 and is configured to revolve and rotate along with the rotation of the sun gear 2 and the internal gear 3, an upper surface plate 5 and a lower surface plate 6 that each have a polishing pad 7 attached thereto and are capable of sandwiching a workpiece 1 to be polished that is held
20 by the carrier 4, and a polishing liquid supplying unit (not shown) that supplies a polishing liquid between the upper surface plate 5 and the lower surface plate 6.

[0031]

With this double-side polishing machine, during polishing processing, the workpiece 1 to be polished, namely, a glass substrate, held by the carrier 4 is
25 sandwiched by the upper surface plate 5 and the lower surface plate 6, and both upper and lower surfaces of the workpiece 1 to be polished are polished by revolution and rotation of the carrier 4 along with the rotation of the sun gear 2 and the internal gear 3, with a polishing liquid being supplied between the workpiece 1 to be polished and the polishing pads 7 attached respectively to the upper and

lower surface plates 5 and 6.

[0032]

The polishing pad particularly for use in the final polishing is preferably a polishing pad (suede pad) with a soft polisher. The polishing pad preferably has an Asker C hardness of 60 to 80. The surface of the polishing pad that is brought into contact with the glass substrate is preferably made of a foamed resin having open foam pores, specifically foamed polyurethane. By polishing the glass substrate in this way, the glass substrate surface can be polished into a smooth mirror-finished surface.

10 [0033]

According to the first embodiment of the present invention, as described in aspect 1 given above, for example, in glass substrate cleaning processing, which is performed after polishing processing of polishing a main surface of a glass substrate, the glass substrate containing at least one component of sodium and potassium in a glass component, cleaning processing is performed a plurality of the glass substrates having a main surface polished into a mirror-finished surface by using a cleaning liquid containing an alkaline agent that is free of sodium and potassium, and maintaining a condition in which the total concentration of sodium ions and potassium ions in the cleaning liquid is 4.00×10^{-3} mol/L or less.

20 [0034]

Conventionally, it has been generally recognized that the increase in the surface roughness of the glass substrate after alkaline cleaning depends only on the alkalinity (pH) of the alkaline agent, and thus the increase in the surface roughness becomes large when strong alkali is used, but the present inventors found that not only the alkalinity of the alkaline agent for use in cleaning, but also the concentration of alkali metal ions such as sodium ions and potassium ions in the cleaning liquid has a great influence on the amount of increase in the surface roughness of the glass substrate.

[0035]

For example, when strong alkali such as KOH or NaOH is used as the alkaline agent, it is possible to obtain the effect of removing extraneous matter resulting from good etching performance, but the increase in the surface roughness of the glass substrate after cleaning is large. The investigations conducted by the present inventors have revealed that, in this case, not only the alkalinity of the alkaline agent, but also the presence of positive ions such as potassium ions or sodium ions is also responsible for the increase in the surface roughness of the substrate.

[0036]

Accordingly, in order to suppress the total amount of sodium ions and potassium ions in the alkaline cleaning liquid, the present inventors found that, specifically, it is preferable to perform cleaning processing by using a cleaning liquid containing an alkaline agent that is free of sodium and potassium and maintaining a condition in which the total concentration of sodium ions and potassium ions in the cleaning liquid is 4.00×10^{-3} mol/L or less. With this configuration, it is possible to obtain the etching performance produced by the OH ions of the alkaline agent contained in the cleaning liquid, and at the same time, by suppressing the amount of sodium ions and potassium ions that are present in the cleaning liquid, the increase in the surface roughness of the glass substrate can be suppressed. In particular, it is preferable to perform the cleaning processing while suppressing the total concentration of sodium ions and potassium ions in the cleaning liquid to 2.00×10^{-3} mol/L or less, more preferably 0.20×10^{-3} mol/L or less, and most preferably 0.02×10^{-3} mol/L or less.

[0037]

Also, in the case of cleaning a glass substrate containing alkali metal components such as sodium and potassium in a glass component, the concentrations of sodium ions and potassium ions in the cleaning liquid increase due to the sodium ions and potassium ions eluted from the glass during cleaning, but it is preferable to perform the cleaning processing while suppressing the total

concentration of sodium ions and potassium ions in the cleaning liquid due to elution of the glass component to 4.00×10^{-3} mol/L or less.

[0038]

The present invention is particularly preferable for use in situations where, for example, a large number of glass substrates are sequentially cleaned, ending up in using the same cleaning bath for a long period of time, because the increase in the surface roughness of the glass substrate can be suppressed.

[0039]

The present invention is applied to, for example, cleaning processing for cleaning the glass substrate, which is performed after polishing processing of polishing the main surfaces of the glass substrate, but in this case, the glass substrate immediately before being subjected to the cleaning processing has ultra-smooth mirror-finished surfaces having a surface roughness (Ra) of 0.15 nm or less. According to the present invention, because the increase in the surface roughness of the substrate caused by alkaline cleaning can be suppressed, the ultra-smooth surface roughness of the substrate obtained in the polishing step can be maintained without compromising the ultra-smooth surface roughness as much as possible.

In the present invention, it is possible to cause the difference between the surface roughness (Ra) of the main surface of the glass substrate after being subjected to the cleaning processing and the surface roughness (Ra) of the main surface of the glass substrate immediately before being subjected to the cleaning processing to be within 0.06 nm, preferably 0.05 nm or less, more preferably 0.03 nm or less, and even more preferably 0.01 nm or less.

In other words, according to the present invention, the increase in the surface roughness of the substrate caused by alkaline cleaning can be suppressed.

[0040]

In the present invention, as the alkaline agent contained in the cleaning

liquid, an alkaline agent that is free of sodium and potassium is used.

The present inventors found that it is preferable to use, as the alkaline agent, for example, tetramethyl ammonium hydroxide (hereinafter referred to simply as "TMAH").

5 Because TMAH does not contain alkali metal ions (positive ions) such as potassium ions and sodium ions despite the fact that TMAH has a high level of alkalinity (for example, equal to that of KOH) and a great extraneous matter removing effect produced by etching performance with respect to glass, it is possible to perform cleaning processing while maintaining a condition in which the
10 total concentration of sodium ions and potassium ions in the cleaning liquid is 4.00×10^{-3} mol/L or less, and as a result, it is possible to obtain the effect of removing extraneous matter resulting from good etching performance, and the increase in the surface roughness of the substrate after cleaning is small. Accordingly, as a result of cleaning the glass substrate by using a cleaning liquid containing TMAH
15 as the alkaline cleaning agent, a low surface roughness (a high level of smoothness) can be achieved in the glass substrate after cleaning, good cleaning performance can be obtained, and a high level of cleanliness can be achieved.

Other than TMAH, it is also possible to use, for example, tetraalkyl ammonium hydroxides such as tetraethyl ammonium hydroxide (hereinafter
20 referred to simply as "TEAH"), tetrapropyl ammonium hydroxide (hereinafter referred to simply as "TPAH") and tetrabutyl ammonium hydroxide (hereinafter referred to simply as "TBAH"). These organic alkaline agents are easily soluble in water and strongly alkaline.

[0041]

25 The mechanism for suppressing the increase in the surface roughness of the substrate after cleaning with the use of these organic alkaline agents is not clearly known, but may be explained as follows. Specifically, in the case of potassium ions and sodium ions, when they bond to OH groups (external silanol groups and internal silanol groups generated through hydrolysis of siloxane bonds

(O-Si-O bonds)) on the glass substrate surface, in order to selectively enhance the etching rate of the bonding portions, the etching rate on the glass substrate surface varies, which is considered to cause an increase in the surface roughness. In the case of the organic alkaline agents listed above, it is considered that even when the organic alkaline agent bonds to OH groups on the glass surface, the increase in the etching rate does not occur. Also, because the organic alkaline agent bonds first to the OH groups on the glass substrate surface, it is considered that there is an effect of suppressing bonding of Na ions and K ions to the OH groups, which occurs afterward. For this reason, by performing cleaning processing by using a cleaning liquid containing any one of the aforementioned organic alkaline agents while suppressing the amount of sodium ions and potassium ions contained in the cleaning liquid, the increase in the surface roughness of the substrate after cleaning can be suppressed. Accordingly, a low surface roughness (a high level of smoothness) can be achieved in the glass substrate after cleaning, good cleaning performance can be obtained, and a high level of cleanliness can be achieved.

[0042]

There is no particular limitation on the amount of organic alkaline agent such as TMAH in the cleaning liquid, but the amount of organic alkaline agent is preferably 0.005 mol/L or more. If the amount of organic alkaline agent such as TMAH is less than 0.005 mol/L, the etching rate decreases, and as a result, it may take time to obtain the extraneous matter removing effect produced by etching performance with respect to glass, and consequently the productivity may be compromised. In addition, the effect of suppressing bonding of Na ions and K ions to the OH groups, which occurs afterward, produced by the organic alkaline agent such as TMAH bonding first to the OH groups on the glass substrate surface may become small. If, on the other hand, the amount of organic alkaline agent such as TMAH is greater than 1 mol/L, although sufficient alkaline cleaning performance can be obtained, the etching rate with respect to glass becomes too

fast, which may make it difficult to control the cleaning time. Also, in the case where the glass composition contains sodium and potassium, the amount of elution of sodium ions and potassium ions increases, and it may become necessary to frequently perform an adjustment operation of adjusting sodium ions and potassium ions in the cleaning liquid (replacement of the cleaning liquid or the like). In addition, the alkalinity becomes too strong, and thus care needs to be taken to handle the cleaning liquid. For this reason, the amount of TMAH is preferably 1 mol/L or less. From this point of view, the amount of TMAH is more preferably 0.005 mol/L to 1 mol/L, and even more preferably within a range of 0.05 to 0.5 mol/L.

[0043]

Also, for the purpose of enhancing the cleaning effect by preventing extraneous matter that has been removed from the substrate surface by the alkaline agent from again adhering to the substrate surface, the cleaning liquid may further contain, in addition to the organic alkaline agent such as TMAH, a cleaning agent (additive) such as a surfactant (including a chelating agent and a dispersing agent) as appropriate.

The surfactant that can be preferably used in the present invention is a surfactant that is free of sodium and potassium.

Examples of the surfactant that can be preferably used in the present invention include anion surfactants such as an alkylarylsulfonate salt, and non-ionic surfactants such as polyoxyethylene alkyl ether and a polyoxyethylene derivative. Other examples include chelating agents such as an organic acid salt of an amino carboxylic acid such as EDTA, and dispersing agents such as phosphate, sulfate and a polymer dispersing agent.

The surfactant and the like described above are preferably contained in an amount of about 2.00×10^{-3} to 1.00×10^{-1} mol/L.

[0044]

As the cleaning agents including a surfactant described above, it is

possible to use those mixed with alkali salts (potassium salt, sodium salt and the like), but in this case as well, it is preferable to perform the cleaning processing while suppressing the total amount of sodium ions and potassium ions in the cleaning liquid to 4.00×10^{-3} mol/L or less, more preferably to 2.00×10^{-3} mol/L or less, and even more preferably to 0.20×10^{-3} mol/L or less.

To this end, it is preferable that these additives do not contain the aforementioned ions in the molecular structure. Specifically, a salt with quaternary ammonium ions such as tetramethyl ammonium ions is preferable. By doing so, the amount of additives can be increased without increasing the amount of sodium ions and potassium ions. Also, if sodium and potassium are contained as unavoidable impurities during synthesis of an additive, the additive is preferably subjected to purification processing using an ion-exchange resin or the like such that the amount of sodium ions and potassium ions is reduced, before use. Then, it is preferable to set the total amount of sodium ions and potassium ions in the cleaning liquid including those contained in the molecular structure and those contained as impurities to be within the above range.

[0045]

As the cleaning liquid for cleaning a magnetic disk glass substrate preferably used in the cleaning processing of the present invention, it is possible to use a cleaning liquid containing at least an organic alkaline agent such as tetramethyl ammonium hydroxide and a surfactant that is free of sodium and potassium.

[0046]

Also, in the present invention, the cleaning liquid preferably has a pH of 10 or more, more preferably 11 or more, and even more preferably 12 or more. According to the present invention, even if the cleaning liquid has a high level of pH (strongly alkaline), because the increase in the surface roughness of the substrate is small, cleaning that provides a high level of cleanliness can be carried out while suppressing the increase in the surface roughness. Note that if the

cleaning liquid has a pH greater than 13, care needs to be taken to handle the cleaning liquid, and it is therefore preferable that the pH is 13 or less.

[0047]

The cleaning processing is usually performed by bringing the glass
5 substrate that has undergone, for example, a polishing step into contact with (for example, immersing the glass substrate in) a cleaning bath accommodating a cleaning liquid containing an alkaline agent such as TMAH and necessary additives including a surfactant as described above. At this time, in order to enhance the cleaning effect, it is preferable to apply ultrasonic waves. The liquid
10 temperature of the cleaning liquid, the cleaning time and the like can be set as appropriate.

[0048]

Another embodiment related to the first embodiment of the present invention relates to a method for manufacturing a glass substrate for a magnetic
15 disk including glass substrate cleaning processing, wherein a relationship between an amount of increase in surface roughness (Ra) of a main surface of the glass substrate after being subjected to the cleaning processing with respect to that before being subjected to the cleaning processing and a total concentration of sodium ions and potassium ions in a cleaning liquid used in the cleaning
20 processing is obtained in advance, the total concentration of sodium ions and potassium ions in the cleaning liquid is determined based on the obtained relationship such that the amount of increase in the surface roughness (Ra) is 0.06 nm or less, and the cleaning processing is performed on the glass substrate having a main surface polished into a mirror-finished surface by maintaining a
25 condition in which the total concentration of sodium ions and potassium ions in the cleaning liquid is less than or equal to the determined concentration.

According to this embodiment, the cleaning processing can be performed such that the amount of increase in the surface roughness of the glass substrate caused by cleaning is less than or equal to a predetermined value.

[0049]

Another embodiment related to the first embodiment of the present invention relates to a method for manufacturing a glass substrate for a magnetic disk including glass substrate cleaning processing, wherein the glass substrate
5 contains at least one component of sodium and potassium in a glass component, and cleaning processing is performed on the glass substrate having a main surface polished into a mirror-finished surface by using a cleaning liquid containing an alkaline agent that is free of sodium and potassium, and performing
10 replacement of the cleaning liquid if a total concentration of sodium ions and potassium ions in the cleaning liquid exceeds 4.00×10^{-3} mol/L.

[0050]

According to this embodiment, even if, for example, a large number of glass substrates are sequentially cleaned, ending up in using the same cleaning bath for a long period of time, by replacing the cleaning liquid with a new cleaning
15 liquid if the total concentration of sodium ions and potassium ions in the cleaning liquid exceeds 4.00×10^{-3} mol/L, the total concentration of sodium ions and potassium ions in the cleaning liquid can be suppressed to 4.00×10^{-3} mol/L or less, and thus the increase in the surface roughness of the glass substrate can be suppressed.

20 [0051]

(Second Embodiment)

According to a second embodiment of the present invention, as described in aspect 11 given above, for example, in cleaning processing for cleaning a glass substrate by using a cleaning liquid containing a cleaning agent, which is
25 performed after polishing processing of polishing a main surface of the glass substrate, the cleaning processing includes processing of bringing the glass substrate into contact with the cleaning liquid having etchability with respect to the glass substrate and containing tetramethyl ammonium ions.

More preferably, as described in aspect 10 given above, the cleaning

processing includes processing of bringing the glass substrate to a cleaning liquid containing tetramethyl ammonium ions, and the cleaning processing is performed while suppressing the total amount of sodium ions and potassium ions in the cleaning liquid to less than 200 ppm.

5 [0052]

The present inventors searched for a method for suppressing the increase in the surface roughness of the substrate while maintaining the cleaning power obtained by alkaline cleaning, and found that the use of a specific alkaline agent, namely, tetramethyl ammonium hydroxide (hereinafter referred to simply as

10 "TMAH") specifically suppresses the increase in the surface roughness.

Despite the fact that TMAH has a high level of alkalinity (for example, equal to that of KOH) and a great extraneous matter removing effect produced by etching performance with respect to glass, the increase in the surface roughness of the substrate after cleaning is small. Accordingly, as a result of cleaning the

15 glass substrate by using a cleaning liquid containing TMAH as the alkaline cleaning agent, a low surface roughness (a high level of smoothness) can be achieved in the glass substrate after cleaning, good cleaning performance can be obtained, and a high level of cleanliness can be achieved.

[0053]

20 The mechanism for suppressing the increase in the surface roughness of the substrate after cleaning by inclusion of TMAH is not clearly known, but may be explained as follows. Specifically, in the case of potassium ions and sodium ions, when they bond to OH groups (external silanol groups and internal silanol groups generated through hydrolysis of siloxane bonds (O-Si-O bonds)) on the glass

25 substrate surface, in order to selectively enhance the etching rate of the bonding portions, the etching rate on the glass substrate surface varies, which is considered to cause an increase in the surface roughness. In the case of TMAH, however, it is considered that even when TMAH bonds to OH groups on the glass surface, the increase in the etching rate does not occur. Also, because TMAH

bonds first to the OH groups on the glass substrate surface, it is considered that there is an effect of suppressing bonding of Na ions and K ions to the OH groups, which occurs afterward. For this reason, by performing the cleaning processing by using a cleaning liquid containing TMAH while suppressing the amount of sodium ions and potassium ions contained in the cleaning liquid, the increase in the surface roughness of the substrate after cleaning can be suppressed. Accordingly, a low surface roughness (a high level of smoothness) can be achieved in the glass substrate after cleaning, good cleaning performance can be obtained, and a high level of cleanliness can be achieved.

10 [0054]

There is no particular limitation on the amount of TMAH in the cleaning liquid, but the amount of TMAH is, for example, preferably 0.005 mol/L or more. If the amount of TMAH is less than 0.005 mol/L, the etching rate decreases, and as a result, it may take time to obtain the extraneous matter removing effect produced by etching performance with respect to glass, and consequently the productivity may be compromised. In addition, the effect of suppressing bonding of Na ions and K ions to the OH groups, which occurs afterward, produced by TMAH bonding first to the OH groups on the glass substrate surface may become small. If, on the other hand, the amount of TMAH is greater than 1 mol/L, although sufficient alkaline cleaning performance can be obtained, the etching rate with respect to glass becomes too fast, which may make it difficult to control the cleaning time. Also, in the case where the glass composition contains sodium and potassium, the amount of elution of sodium ions and potassium ions increases, and it may become necessary to frequently perform an adjustment operation of adjusting sodium ions and potassium ions in the cleaning liquid (replacement of the cleaning liquid or the like). In addition, the alkalinity becomes too strong, and thus care needs to be taken to handle the cleaning liquid. For this reason, the amount of TMAH is preferably 1 mol/L or less. From this point of view, the amount of TMAH is more preferably 0.005 mol/L to 1 mol/L, and even more

preferably within a range of 0.05 to 0.5 mol/L.

[0055]

Also, conventionally, it has been generally recognized that the increase in the surface roughness of the glass substrate after alkaline cleaning depends only on the alkalinity (pH) of the alkaline agent, and thus the increase in the surface roughness becomes large when strong alkali is used, but the present inventors found that not only the alkalinity of the alkaline agent for use in cleaning, but also the type of positive ions that pair with OH ions has a great influence on the amount of increase in the surface roughness.

[0056]

For example, when strong alkali such as KOH and NaOH is used as the alkaline agent, it is possible to obtain the effect of removing extraneous matter resulting from good etching performance, but the increase in the surface roughness of the glass substrate after cleaning is large. The investigations conducted by the present inventors have revealed that, in this case, not only the alkalinity of the alkaline agent, but also the presence of positive ions such as K ions and Na ions is also responsible for the increase in the surface roughness of the substrate.

[0057]

Based on the above, the present inventors found that it is preferable to perform cleaning processing while suppressing the total amount of Na ions and K ions in the alkaline cleaning liquid to less than 200 ppm. By doing so, the etching performance produced by the OH ions in the alkaline agent contained in the cleaning liquid is obtained, and at the same time, by suppressing the amount of Na ions and K ions that are present in the cleaning liquid, the increase in the surface roughness of the substrate can be suppressed. In particular, it is preferable to perform cleaning processing while suppressing the total amount of Na ions and K ions in the alkaline cleaning liquid to 10 ppm or less, and more preferably to 1 ppm or less.

The amount of Na ions and K ions in the cleaning liquid can be measured by, for example, ion chromatography or an ICP method using the cleaning liquid sampled from the cleaning bath.

As used herein, "ppm" refers to mass ppm (the mass ratio expressed in parts by million).
[0058]

In the case where TMAH is used as described above, no influence is caused by the presence of Na ions and K ions in the cleaning liquid, and thus as described above, it is possible to obtain the effect of removing extraneous matter resulting from good etching performance, and the increase in the surface roughness of the substrate after cleaning can be suppressed.
[0059]

Also, in the case of cleaning a glass substrate containing alkali metal components such as sodium and potassium in a glass component, it is preferable to perform the cleaning step while suppressing the total amount of Na ions and K ions in the alkaline cleaning liquid due to elution of the glass component to less than 100 ppm.
[0060]

Also, for the purpose of enhancing the cleaning effect by preventing extraneous matter that has been removed from the substrate surface by the alkaline agent from again adhering to the substrate surface, the cleaning liquid may further contain, in addition to TMAH described above, a cleaning agent (additive) such as a surfactant, a chelating agent or a dispersing agent as appropriate.

Examples of the surfactant that can be preferably used in the present invention include anion surfactants such as an alkyl sulfate ester, fatty acid and an alkylarylsulfonate salt, and non-ionic surfactants such as polyoxyethylene alkyl ether and a polyoxyethylene derivative. Examples of the chelating agent include an amino carboxylic acid such as EDTA, and a salt of an organic acid such as

citric acid. Examples of the dispersing agent include phosphate, sulfate, and a polymer dispersing agent.

The surfactant and the like described above are preferably contained in an amount of about 2.00×10^{-3} to 1.00×10^{-1} mol/L.

5 [0061]

However, the cleaning agents (additives) including a surfactant, a chelating agent and a dispersing agent described above are usually mixed with alkali metal salts (potassium salt, sodium salt and the like), and thus when these cleaning agents are contained in the cleaning liquid, it is preferable to perform the
10 cleaning processing while suppressing the total amount of sodium ions and potassium ions in the cleaning liquid to less than 200 ppm. More preferably, the cleaning processing is performed while suppressing the total amount of sodium ions and potassium ions in the cleaning liquid to 100 ppm or less, and even more preferably to 10 ppm or less.

15 To this end, it is preferable that these additives do not contain the aforementioned ions in the molecular structure. Specifically, a salt with tetramethyl ammonium ions is preferable. By doing so, the amount of additives can be increased without increasing the amount of sodium ions and potassium ions. Also, if sodium and potassium are contained as unavoidable impurities
20 during synthesis of an additive, the additive is preferably subjected to purification processing using an ion-exchange resin or the like such that the amount of sodium ions and potassium ions is reduced, before use. Then, it is preferable to set the total amount of sodium ions and potassium ions in the cleaning liquid including those contained in the molecular structure and those contained as impurities to be
25 within the above range.

[0062]

The cleaning processing is usually performed by bringing the glass substrate that has undergone, for example, a polishing step into contact with (for example, immersing the glass substrate in) a cleaning bath accommodating a

cleaning liquid containing TMAH described above and necessary additives. At this time, in order to enhance the cleaning effect, it is preferable to apply ultrasonic waves. The liquid temperature of the cleaning liquid, the cleaning time and the like can be set as appropriate.

5 [0063]

In the present invention, it is possible to cause the difference between the surface roughness (Ra) of the main surface of the glass substrate after being subjected to the cleaning processing and the surface roughness (Ra) of the main surface of the glass substrate before being subjected to the cleaning processing to
10 be within 0.06 nm, preferably 0.05 nm or less, more preferably 0.03 nm or less, and even more preferably 0.01 nm or less.

That is, according to the present invention, it is possible to suppress the increase in the surface roughness of the substrate caused by alkaline cleaning. If the increase in the surface roughness of the substrate can be suppressed to be
15 within 0.06 nm, the substrate surface having an ultra-low surface roughness obtained by second main surface polishing, which will be described later, is not significantly changed, and it is therefore possible to enhance cleanliness while maintaining the ultra-low surface roughness.

[0064]

20 Also, it is preferable that the main surface of the glass substrate before being subjected to the cleaning processing has a surface roughness (Ra) of 0.13 nm or less. In particular, the main surface of the glass substrate before being subjected to the cleaning processing is preferably an ultra-smooth surface with a surface roughness (Ra) of 0.10 nm or less. According to the present invention,
25 the increase in the surface roughness of the substrate caused by alkaline cleaning can be suppressed, and thus the ultra-smooth surface roughness of the substrate obtained in polishing processing can be maintained without compromising the ultra-smooth surface roughness as much as possible.

[0065]

Also, in the present embodiment as well, the cleaning liquid preferably has a pH of 10 or more, more preferably 11 or more, and even more preferably 12 or more. According to the present invention, even if a cleaning liquid having a high level of pH (strongly alkaline) is used in order to enhance the effect of removing extraneous matter produced by etching, because the increase in the surface roughness of the substrate is small, cleaning that provides a high level of cleanliness can be carried out. Note that if the cleaning liquid has a pH greater than 13, care needs to be taken to handle the cleaning liquid, and it is therefore preferable that the pH is 13 or less.

10 [0066]

Generally, the polishing processing is usually performed in two stages: first polishing processing for removing cracks or distortion remaining on the substrate surface after the lapping step described above; and second polishing processing for polishing the main surface of the glass substrate into a smooth mirror-finished surface while maintaining the flat surface obtained through the first polishing processing (note that the polishing processing may be performed in multiple stages of 3 or more). In this case, it is preferable to perform the cleaning processing of the present invention as cleaning processing that is performed after at least the second polishing processing performed in the latter stage, or in other words, the final polishing processing of the multiple-stage polishing processing. According to the present invention, cleaning that provides a high level of cleanliness can be performed without compromising a smooth mirror-finished surface obtained through the final polishing processing as much as possible.

[0067]

25 In the present invention, it is preferable that glass (the type of glass) constituting the glass substrate is aluminosilicate glass, and 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. As such aluminosilicate glass, it is possible to use

aluminosilicate glass that contains SiO_2 in an amount of 58 wt% to 75 wt%, Al_2O_3 in an amount of 5 wt% to 23 wt%, Li_2O in an amount of 3 wt% to 10 wt%, and Na_2O in an amount of 4 wt% to 13 wt% as main components (note that the aluminosilicate glass does not contain a phosphorus oxide). Furthermore, for
 5 example, it is also possible to use phosphorus oxide-free amorphous aluminosilicate glass that contains SiO_2 in an amount of 62 wt% to 75 wt%, Al_2O_3 in an amount of 5 wt% to 15 wt%, Li_2O in an amount of 4 wt% to 10 wt%, Na_2O in an amount of 4 wt% to 12 wt%, and ZrO_2 in an amount of 5.5 wt% to 15 wt% as main components, and has an $\text{Na}_2\text{O}/\text{ZrO}_2$ weight ratio of 0.5 to 2.0 and an $\text{Al}_2\text{O}_3/\text{ZrO}_2$
 10 weight ratio of 0.4 to 2.5.

It is also possible to use glass having a composition of SiO_2 in an amount of 58 to 66 wt%, Al_2O_3 in an amount of 13 to 19 wt%, Li_2O in an amount of 3 to 4.5 wt%, Na_2O in an amount of 6 to 13 wt%, K_2O in an amount of greater than 0 and 5 wt% or less, R_2O (where, $\text{R}_2\text{O} = \text{Li}_2\text{O} + \text{Na}_2\text{O} + \text{K}_2\text{O}$) in an amount of 10 to 18 wt%,
 15 MgO in an amount of 0 to 3.5 wt%, CaO in an amount of 1 to 7 wt%, SrO in an amount of 0 to 2 wt%, BaO in an amount of 0 to 2 wt%, RO (where $\text{RO} = \text{MgO} + \text{CaO} + \text{SrO} + \text{BaO}$) in an amount of 2 to 10 wt%, TiO_2 in an amount of 0 to 2 wt%, CeO_2 in an amount of 0 to 2 wt%, Fe_2O_3 in an amount of 0 to 2 wt%, MnO in an amount of 0 to 1 wt%, where $\text{TiO}_2 + \text{CeO}_2 + \text{Fe}_2\text{O}_3 + \text{MnO} = 0.01$ to 3 wt%.

20 [0068]

As a characteristic of next-generation substrates, heat resistance may be required. In this case, 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 6 mol%,; BaO in an amount of 0 to 2 mol%; Li_2O in an amount of 0 to 3 mol%; ZnO
 25 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 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.

[0069]

In the present invention, the surface of a glass substrate after the aforementioned grinding processing preferably has an arithmetic average roughness Ra of 0.20 nm or less, particularly 0.15 nm or less, and further preferably 0.10 nm or less. Furthermore, the maximum surface roughness Rmax is preferably 2.0 nm or less, particularly preferably 1.5 nm or less, and even more preferably 1.0 nm or less. Ra and Rmax as used in the present invention both denote roughness that is calculated in accordance with the Japanese Industrial Standards (JIS) B 0601. These surfaces are preferably mirror-finished surfaces.

From a practical viewpoint, the surface roughness (for example, maximum roughness Rmax, arithmetic average roughness Ra) in the present invention is preferably the surface roughness of a surface shape obtained by performing a measurement on an area of $1\ \mu\text{m} \times 1\ \mu\text{m}$ under an atomic force microscope (AFM) at a resolution of 512×512 pixels.

[0070]

In the present invention, it is preferable to perform a chemical strengthening treatment before or after the polishing processing. As a method for the chemical strengthening treatment, it is preferable to use, for example, a low-temperature ion-exchange method that performs ion exchange in a temperature range not exceeding the glass transition point, for example, at a temperature of 300°C or greater and 400°C or less. The chemical strengthening treatment is a treatment in which a 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, 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 treatment has excellent

impact resistance, and it is therefore particularly preferable to mount the glass substrate on, for example, an HDD for mobile use. As the chemical strengthening salt, an alkali metal nitrate such as potassium nitrate or sodium nitrate can be preferably used.

5 [0071]

According to the method for manufacturing a glass substrate for a magnetic disk according to the present invention, as shown in FIGS. 1 and 2, a disk-shaped glass substrate 1 having two main surfaces 11, an outer circumferential end face 12 and an inner circumferential end face 13 located
10 between the main surfaces 11 is obtained. The outer circumferential end face 12 is composed of a side wall face 12a, and chamfered faces 12b located, on both sides of the side wall face 12a, between the side wall face 12a and the main surfaces. The inner circumferential end face 13 has the same shape.

[0072]

15 The present invention also provides a method for manufacturing a magnetic disk using the above-described magnetic disk glass substrate. In the present invention, the magnetic disk is manufactured by forming at least a magnetic layer on the magnetic disk glass substrate of the present invention. As a material of the magnetic layer, hexagonal-system CoCrPt-based or CoPt-based
20 ferromagnetic alloy with a large anisotropic magnetic field can be used. The magnetic layer is preferably formed on the glass substrate by a sputtering method, for example, a DC magnetron sputtering method. Interposing an underlayer 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
25 example, use of a hexagonal-system underlayer 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 underlayer can be formed in the same manner as the magnetic layer by a

sputtering method.

[0073]

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

Use of the magnetic disk glass substrate obtained according to the present invention makes it possible to obtain a highly reliable magnetic disk.

15 Examples

[0074]

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

20 (Example 1)

A magnetic disk glass substrate of this example was manufactured through (1) rough grinding processing, (2) shaping processing, (3) precision grinding processing, (4) end face polishing processing, (5) first main surface polishing processing, (6) chemical strengthening processing, (7) second main
25 surface polishing processing, and (8) cleaning processing as described below.

[0075]

First, a disk-shaped glass substrate made of aluminosilicate glass was obtained from molten glass by direct pressing using upper, lower, and drum molds. Other than using such direct pressing, a glass substrate may also be obtained by

cutting plate glass that has been produced by a downdraw method or a float method into a glass substrate with a predetermined size. As this aluminosilicate glass, glass for chemical strengthening containing SiO_2 in an amount of 58 to 75 wt%, Al_2O_3 in an amount of 5 to 23 wt%, Li_2O in an amount of 3 to 10 wt%, and
5 Na_2O in an amount of 4 to 13 wt% was used.

[0076]

(1) Rough grinding processing

Next, rough grinding processing was performed on this glass substrate to improve the dimensional accuracy and shape accuracy. This rough grinding
10 processing was performed using a double-side grinding machine and loose abrasive particles. Specifically, the glass substrate that was held by a carrier was tightly placed between the upper and lower surface plates, and the sun gear and the internal gear of the grinding machine were rotated while supplying a liquid containing loose abrasive grains between the glass substrate and the surface
15 plates, so as to grind both main surfaces of the glass substrate accommodated in the carrier.

[0077]

(2) Shaping processing

Next, a cylindrical grindstone was used to create a hole in the center of the
20 glass substrate, and the outer circumferential end face was ground. After that, predetermined chamfering processing was performed on the outer circumferential end face and the inner circumferential end face. Generally, a magnetic disk with an outer diameter of 65 mm is used in a 2.5-inch HDD (hard disk drive).

[0078]

25 (3) Precision grinding processing

Using a double-side grinding machine, this precision grinding processing was performed while the glass substrate that was held by a carrier was tightly placed between the upper and lower surface plates to which pellets containing diamond abrasive particles fixed with a resin were attached.

Specifically, the sun gear and the internal gear of the grinding machine were rotated while supplying a coolant between the glass substrate and the surface plates, so as to grind both main surfaces of the glass substrate accommodated in the carrier.

5 [0079]

(4) End face polishing processing

Next, the end faces (inner and outer circumferential end faces) of the glass substrate were brush-polished to a mirror finish while the glass substrate was rotated.

10 [0080]

(5) First main surface polishing processing

Next, first polishing processing was performed using a double-side polishing machine as described above with reference to FIG. 3. In the double-side polishing machine, the glass substrate that was held by a carrier 4 was tightly placed

15 between upper and lower surface plates 5 and 6 each having a polishing pad 7 attached thereto, the carrier 4 was engaged with a sun gear 2 and an internal gear 3, and the glass substrate was pressed between the upper and lower surface plates 5 and 6. After that, the carrier 4 was rotated while supplying a polishing liquid between the polishing pads and the surfaces of the glass substrate to be polished,
20 and thereby the glass substrate made an orbital motion while rotating on its axis on the surface plates 5 and 6 so that both main surfaces of the glass substrate were polished simultaneously. Specifically, the first polishing processing was performed using a hard polisher (hard urethane foam) as a polisher. As the polishing liquid, a polishing liquid prepared by dispersing cerium oxide (average particle size (D50) of
25 1 μm) serving as an abrasive in water was used.

[0081]

(6) Chemical strengthening processing

Next, chemical strengthening was performed on the glass substrate that had undergone the aforementioned cleaning. Chemical strengthening processing

was performed by providing a chemical strengthening solution in which potassium nitrate and sodium nitrate were mixed and molten, and immersing the glass substrate in the chemical strengthening solution.

[0082]

5 (7) Second main surface polishing processing

Next, second polishing processing was performed using the same double-side polishing machine as used in the first polishing processing, but polishing pads with a soft polisher (suede) (polyurethane foam with an Asker C hardness of 72) was used. This second polishing processing is mirror-polishing processing to finish the main surfaces of the glass substrate into smooth mirror surfaces with a surface roughness of, for example, 2 nm or less in R_{max} while maintaining the flat surfaces obtained in the first polishing processing described above. As the polishing liquid, a polishing liquid prepared by dispersing colloidal silica (average particle size (D50) of 15 nm) as an abrasive in water, the colloidal silica being produced through hydrolysis of an organosilicon compound, and adjusted to be acidic ($pH = 2$) by adding sulfuric acid was used.

15 [0083]

(8) Cleaning processing

Next, cleaning processing of cleaning the glass substrate that had undergone the second polishing processing was performed. Specifically, fifty glass substrates as one batch were immersed for 600 seconds in a cleaning bath (liquid temperature: room temperature) accommodating a cleaning liquid No. 1 (pH of 12.6) prepared by adding TMAH serving as an alkaline cleaning agent to pure water at a concentration of 0.3 mol/L. After that, the glass substrates were immersed in another cleaning bath (pure water, room temperature) so as to perform ultrasonic cleaning at 80 kHz for 300 seconds, and dried.

25 [0084]

Before the cleaning processing, the concentration of alkali metal ions (sodium ions and potassium ions) in the cleaning liquid No. 1 was measured and

found to be 0 (zero, not greater than the detection limit value). The concentration of alkali metal ions can be measured by, for example, ion chromatography using the cleaning liquid sampled from the cleaning bath.

Also, the surface roughness (Ra) of the main surfaces of the glass substrate after being subjected to the cleaning processing and the surface roughness (Ra) of the main surfaces of the glass substrate before being subjected to the cleaning processing (or in other words, after the second polishing step) were measured under an atomic force microscope (AFM), and the difference (ΔRa : the value obtained by subtracting Ra measured before the cleaning processing from Ra measured after the cleaning processing) was calculated. The value of surface roughness is an average value of fifty glass substrates. As a result, ΔRa was 0.006 nm. Ra measured before the cleaning processing was 0.14 nm.

[0085]

Then, another fifty glass substrates as one batch were immersed in the above-described cleaning bath so as to perform cleaning processing. In the same manner, each batch of fifty glass substrates was sequentially subjected to cleaning processing in the above-described cleaning bath without performing replacement of the cleaning liquid. In the present example, the glass substrates contained Na, and thus the amount of alkali metal ions in the cleaning liquid increased gradually as the number of times of cleaning processing increased.

The concentration of alkali metal ions (sodium ions and potassium ions) in the cleaning liquid was measured each time fifty glass substrates were immersed. Also, with respect to the fifty glass substrates that had undergone cleaning, calculation was performed in the same manner as described above using an AFM so as to determine the difference between the surface roughness (Ra) of the main surfaces of the glass substrate after being subjected to the cleaning processing and the previously measured surface roughness (Ra) of the main surfaces of the glass substrate before being subjected to the cleaning processing (or in other words, after the second polishing step) (ΔRa : the value obtained by subtracting Ra

measured before the cleaning processing from Ra measured after the cleaning processing).

The concentration (C) of alkali metal ions in the cleaning liquid and the value of ΔRa are shown in Table 1 (Samples 1 to 5). In addition, the ratio of change of ΔRa relative to the concentration (C) of alkali metal ions, $d(\Delta Ra)/d(C)$, is also shown in Table 1.

[0086]

(Example 2)

Glass substrates were produced by performing cleaning processing in the same manner as in Example 1, except that in the cleaning processing of Example 1, a cleaning liquid No. 2 was used that was prepared by adding, as a cleaning agent, an anion surfactant (tetramethyl ammonium dodecylbenzene sulfonate (quaternary ammonium cation salt), hereinafter referred to simply as "DBS") in an amount of 6.00×10^{-3} mol/L, in addition to TMAH.

In the same manner as in Example 1, the concentration of alkali metal ions (sodium ions and potassium ions) in the cleaning liquid was measured each time fifty glass substrates were immersed, and the value of ΔRa was calculated with respect to the fifty glass substrates that had undergone cleaning.

The concentration (C) of alkali metal ions in the cleaning liquid and the value of ΔRa are shown in Table 1 (Samples 6 to 10). In addition, the ratio of change of ΔRa relative to the concentration (C) of alkali metal ions, $d(\Delta Ra)/d(C)$, is also shown in Table 1.

[0087]

(Example 3)

Glass substrates were produced by performing cleaning processing in the same manner as in Example 1, except that in the cleaning processing of Example 1, cleaning liquids Nos. 3 to 5 were used that were prepared by respectively adding TEAH, TPAH and TBAH instead of TMAH, and also a cleaning liquid No. 6 was used that was prepared by adding, in addition to TMAH,

poly(oxyethylene)nonylphenyl ether having a molecular weight of 660.87 (10EO) (10EO indicating that the number of moles of ethylene oxide added is 10) in an amount of 6.00×10^{-3} mol/L as a non-ionic surfactant.

In the same manner as in Example 1, the concentration of alkali metal ions (sodium ions and potassium ions) in the cleaning liquid was measured each time fifty glass substrates were immersed, and the value of ΔRa was calculated with respect to the fifty glass substrates that had undergone cleaning.

The concentration (C) of alkali metal ions in the cleaning liquid and the value of ΔRa are shown in Table 2 (Samples 11 to 14).

10 [0088]

[Table 1]

		Concentration (C) of alkali metal ions in cleaning liquid (mmol/L)	ΔRa (nm)	$d(\Delta Ra)/d(C) \times 10000$
Sample 1	TMAH	0	0.006	-
Sample 2	TMAH	0.20	0.007	50
Sample 3	TMAH	1.90	0.030	135
Sample 4	TMAH	3.90	0.059	145
Sample 5	TMAH	4.60	0.080	300
Sample 6	TMAH + DBS	0	0.006	-
Sample 7	TMAH + DBS	0.20	0.006	0
Sample 8	TMAH + DBS	1.80	0.025	119
Sample 9	TMAH + DBS	4.00	0.056	141
Sample 10	TMAH + DBS	4.70	0.077	300

[0089]

[Table 2]

		Concentration (C) of alkali metal ions in cleaning liquid (mmol/L)	ΔRa (nm)
Sample 11	TEAH	0.20	0.007
Sample 12	TPAH	0.20	0.007
Sample 13	TBAH	0.20	0.006
Sample 14	TMAH + non-ionic surfactant	0.20	0.007

[0090]

The following facts were found from the results shown in Tables 1 and 2 given above.

1. According to the present invention, the increase in the surface roughness of the substrate after being subjected to the cleaning processing can be suppressed (to 0.06 nm or less) by performing cleaning processing of cleaning a plurality of glass substrates whose main surfaces have been mirror-polished while maintaining a condition in which the total concentration of sodium ions and potassium ions in the cleaning liquid is 4.00×10^{-3} mol/L or less.
2. In contrast, if the total concentration of sodium ions and potassium ions in the cleaning liquid exceeds 4.00×10^{-3} mol/L, the ratio of change of ΔRa relative to the concentration (C) of alkali metal ions, $d(\Delta Ra)/d(C)$, increases abruptly, and the increase in the surface roughness of the substrate after being subjected to the cleaning processing is large (0.077 nm or more).
3. Even when TEAH, TPAH and TBAH were used as a cleaning agent instead of TMAH, by performing cleaning processing of cleaning a plurality of glass substrates whose main surfaces have been mirror-polished while maintaining a condition in which the total concentration of sodium ions and potassium ions in the cleaning liquid is 4.00×10^{-3} mol/L or less, the increase in the surface roughness of the substrate after being subjected to the cleaning processing can be suppressed. In addition, even when a surfactant was added to the cleaning liquid, the same effects were obtained. Although not shown in Table 2, the same results as those of Samples 1 to 10 described above were obtained by further sequentially subjecting fifty glass substrates as one batch to cleaning processing.

[0091]

(Example 4)

Glass substrates were produced under the same conditions as those used for Sample 6 except that colloidal silica (average particle size (D50) of 15 nm)

produced by a water glass method as described above was used. The produced glass substrates were named as Sample 15.

Also, glass substrates were produced under the same conditions as those used for Sample 6 and Sample 15 except that cleaning was performed without using the cleaning bath containing TMAH and an additive (DBS), and the produced glass substrates were named as Sample 6N and Sample 15N, respectively.

Then, the main surfaces of the glass substrates of Samples 6, 15, 6N and 15N were observed by using a laser surface defect inspection apparatus so as to count the number of extraneous matter defects (protrusion defects caused by adhesion of extraneous matter), and the following were calculated:

$(\text{Counted number of Sample 6})/(\text{Counted number of Sample 6N}) \times 100 = A (\%);$ and

$(\text{Counted number of Sample 15})/(\text{Counted number of Sample 15N}) \times 100 = B (\%).$ As a result, the following results were obtained: $A = 3\%$, and $B = 6\%$. Analysis was performed by using a SEM and an EDX, and it was found that most extraneous matter was silica abrasive grains.

That is, it was found that a particularly high cleaning effect is obtained by applying the present invention after performing polishing using colloidal silica produced through hydrolysis of an organosilicon compound (sol-gel method).
[0092]

(Example 5)

A magnetic disk glass substrate of this example was manufactured through (1) rough grinding processing, (2) shaping processing, (3) precision grinding processing, (4) end face polishing processing, (5) first main surface polishing processing, (6) chemical strengthening processing, (7) second main surface polishing processing, and (8) cleaning processing as described below.
[0093]

(1) Rough grinding processing

First, a disk-shaped glass substrate made of aluminosilicate glass and having a diameter of 66 mm and a thickness of 1.0 mm was obtained from molten glass by direct pressing using upper, lower, and drum molds. Other than using such direct pressing, a glass substrate may also be obtained by cutting plate glass that has been produced by a downdraw method or a float method into a glass substrate with a predetermined size. As this aluminosilicate glass, glass for chemical strengthening containing SiO_2 in an amount of 58 to 75 wt%, Al_2O_3 in an amount of 5 to 23 wt%, Li_2O in an amount of 3 to 10 wt%, and Na_2O in an amount of 4 to 13 wt% was used.

10 [0094]

Then, rough grinding processing was performed on this glass substrate to improve the dimensional accuracy and shape accuracy. This grinding processing was performed using a double-side grinding machine and loose abrasive particles made of alumina. Specifically, the glass substrate that was held by a carrier was tightly placed between the upper and lower surface plates, the load was set as appropriate, the sun gear and the internal gear of the lapping machine were rotated, and thus both main surfaces of the glass substrate accommodated in the carrier were roughly ground.

[0095]

20 (2) Shaping processing

Next, a cylindrical grindstone was used to create a hole in the center of the glass substrate, and the outer circumferential end face was ground so as to obtain a diameter of 65 mm. After that, predetermined chamfering processing was performed on the outer circumferential end face and the inner circumferential end face. Generally, a magnetic disk with an outer diameter of 65 mm is used in a 2.5-inch HDD (hard disk drive).

[0096]

(3) Precision grinding processing

Using a double-side grinding machine, this precision grinding processing

was performed while the glass substrate that was held by a carrier was tightly placed between the upper and lower surface plates having fixed abrasive particles attached thereto.

Specifically, the load was set as appropriate, the sun gear and the internal
5 gear of the grinding machine were rotated, and thus both main surfaces of the glass substrate accommodated in the carrier were ground.

[0097]

(4) End face polishing processing

Next, the end faces (inner and outer circumferential end faces) of the
10 glass substrate were brush-polished while the glass substrate was rotated.

[0098]

(5) First main surface polishing processing

Next, first polishing processing to remove cracks or distortion remaining on the substrate surface after the above-described precision grinding processing was
15 performed using a double-side polishing machine as shown in FIG. 3 described above. In the double-side polishing machine, the glass substrate that was held by a carrier 4 was tightly placed between upper and lower surface plates 5 and 6 each having a polishing pad 7 attached thereto, the carrier 4 was engaged with a sun gear 2 and an internal gear 3, and the glass substrate was pressed between
20 the upper and lower surface plates 5 and 6. After that, the carrier 4 was rotated while supplying a polishing liquid between the polishing pads and the surfaces of the glass substrate to be polished, and thereby the glass substrate made an orbital motion while rotating on its axis on the surface plates 5 and 6 so that both main surfaces of the glass substrate were polished simultaneously. Specifically, the
25 first polishing processing was performed using a hard polisher (hard urethane foam) as a polisher. As the polishing liquid, a polishing liquid prepared by dispersing cerium oxide serving as an abrasive in water was used.

[0099]

(6) Chemical strengthening processing

Next, chemical strengthening was performed on the glass substrate that had undergone the aforementioned cleaning. Chemical strengthening processing was performed by providing a chemical strengthening solution in which potassium nitrate and sodium nitrate were mixed and molten, and immersing the glass
5 substrate in the chemical strengthening solution.

[0100]

(7) Second main surface polishing processing

Next, second polishing processing was performed using the same double-side polishing machine as used in the first polishing processing, but
10 polishing pads with a soft polisher (suede) (polyurethane foam with an Asker C hardness of 72) was used. This second polishing processing is mirror-polishing processing to finish the main surfaces of the glass substrate into smooth mirror surfaces with a surface roughness of, for example, about 0.2 nm or less in Ra and 2 nm or less in Rmax while maintaining the flat surfaces obtained in the first
15 polishing processing described above. As the polishing liquid, a polishing liquid prepared by dispersing colloidal silica (average particle size of 15 nm) serving as an abrasive in pure water and adjusted to be acidic (pH = 2) was used.

[0101]

(8) Cleaning processing

20 Next, cleaning processing of the glass substrate that had undergone the second polishing processing was carried out. Specifically, the glass substrate was immersed for 600 seconds in a cleaning bath (liquid temperature: room temperature) accommodating a cleaning liquid (pH of 12.6) prepared by adding TMHA serving as an alkaline cleaning agent to pure water at a concentration of
25 0.3 mol/L. After that, the glass substrate was immersed in another cleaning bath (pure water, room temperature) so as to perform ultrasonic cleaning at 80 kHz for 300 seconds, and dried.

At this time, as the TMAH, TMAH containing no Na ions and K ions (not greater than the detection limit) was used. The cleaning liquid was sampled so

as to check the concentration of Na ions and K ions by using ion chromatography, and as a result, neither of these ions was detected.

[0102]

With respect to hundred glass substrates obtained through the
5 above-described steps, the surface roughness (Ra) of the main surface of the glass substrate after being subjected to the cleaning processing and the surface roughness (Ra) of the main surface of the glass substrate before being subjected to the cleaning processing (or in other words, after the second polishing step) were measured under an atomic force microscope (AFM), and the difference (ΔRa : the
10 value obtained by subtracting Ra measured before the cleaning processing from Ra measured after the cleaning processing) is shown in Table 3. The value of surface roughness is an average value of hundred glass substrates that were manufactured.

The obtained hundred glass substrates were subjected to extraneous
15 matter defect evaluation. The main surfaces of the obtained glass substrates were observed by using a laser surface defect inspection apparatus so as to count the number of extraneous matter defects (protrusion defects caused by adhesion of extraneous matter), and the results are shown in Table 5. The counted number is an average value of hundred glass substrates that were manufactured.

20 In the present example, it was possible to obtain magnetic disk glass substrates having a substrate surface in which the increase in the surface roughness of the substrate caused by alkaline cleaning was suppressed.

[0103]

(Comparative Example 1)

25 Glass substrates were produced in the same manner as in Example 1, except that in the cleaning processing of Example 1, a cleaning liquid prepared by adding KOH serving as an alkaline cleaning agent at a concentration of 0.3 mol/L was used. The concentration of K ions in the cleaning liquid was measured and found to be 12000 ppm. The number of extraneous matter defects counted after

cleaning was 775, which was similar to that of Example 1.

(Comparative Example 2)

Glass substrates were produced in the same manner as in Example 1, except that in the cleaning processing of Example 1, a cleaning liquid prepared by
5 adding NaOH serving as an alkaline cleaning agent at a concentration of 0.3 mol/L was used. The concentration of Na ions in the cleaning liquid was measured and found to be 12000 ppm. The number of extraneous matter defects counted after cleaning was 802, which was similar to that of Example 1.

[0104]

10 (Example 2)

Glass substrates were produced in the same manner as in Example 1, except that in the cleaning processing of Example 1, a cleaning liquid was used that was prepared by adding, as a cleaning agent, an anion surfactant (tetramethyl ammonium dodecylbenzene sulfonate (quaternary ammonium cation salt),
15 hereinafter referred to simply as "DBS") in an amount of 10 mmol/L in addition to TMAH, and that had a total amount of Na ions and K ions in the cleaning liquid of 1 ppm or less. The anion surfactant was purified to remove Na ions and K ions by using an ion-exchange resin such that the total amount of Na ions and K ions in the cleaning liquid was within the above-described range, before use.

20 [0105]

(Example 3)

Glass substrates were produced in the same manner as in Example 2, except that in the cleaning step of Example 2, a cleaning liquid was used that was prepared by changing the purification conditions for purifying DBS such that the
25 total amount of Na ions and K ions in the cleaning liquid was 10 ppm.

[0106]

(Example 4)

Glass substrates were produced in the same manner as in Example 2, except that, in the cleaning step of Example 2, a cleaning liquid was used that was

prepared by changing the purification conditions for purifying DBS such that the total amount of Na ions and K ions in the cleaning liquid was 95 ppm.

[0107]

(Example 5)

- 5 Glass substrates were produced in the same manner as in Example 2, except that, in the cleaning step of Example 2, a cleaning liquid was used that was prepared by changing the purification conditions for purifying DBS such that the total amount of Na ions and K ions in the cleaning liquid was 195 ppm.

[0108]

- 10 (Reference Example)

Glass substrates were produced in the same manner as in Example 2, except that, in the cleaning step of Example 2, a cleaning liquid was used that was prepared by changing the purification conditions for purifying DBS such that the total amount of Na ions and K ions in the cleaning liquid was 221 ppm.

- 15 (Example 6)

Glass substrates were produced in the same manner as in Example 1, except that a cleaning liquid was used that was prepared by adding, in addition to TMAH, poly(oxyethylene)nonylphenyl ether having a molecular weight of 660.87 (10EO) (10EO indicating that the number of moles of ethylene oxide added is 10) and serving as a non-ionic surfactant in an amount of 10 mmol/L, and that had a total amount of Na ions and K ions in the cleaning liquid of 1 ppm or less. The non-ionic surfactant was purified to remove Na ions and K ions by using an ion-exchange resin such that the total amount of Na ions and K ions in the cleaning liquid was within the above-described range, before use.

- 25 [0109]

The glass substrates produced in Examples 2 to 6, Reference Example and Comparative Examples 1 and 2 were subjected to measurement of surface roughness of the main surface, or measurement of surface roughness of the main surface and extraneous matter defect evaluation in the same manner as in

Example 1, and the results are collectively shown in Tables 3, 4 and 5 below.

[0110]

[Table 3]

Table 3	Type of cleaning liquid	Concentration of alkali metal ions in cleaning liquid	ΔRa
Example 1	TMAH	- (not greater than detection limit)	0.005nm
Comparative Example 1	KOH	12000ppm	0.070nm
Comparative Example 2	NaOH	12000ppm	0.071nm

5 [0111]

[Table 4]

Table 4	Type of cleaning liquid	Concentration of alkali metal ions in cleaning liquid	ΔRa
Example 1	TMAH	-	0.005nm
Example 2	TMAH + DBS	1 ppm	0.006nm
Example 3	TMAH + DBS	10 ppm	0.009nm
Example 4	TMAH + DBS	95 ppm	0.030nm
Example 5	TMAH + DBS	195 ppm	0.058nm
Reference Example	TMAH + DBS	221 ppm	0.065nm
Example 6	TMAH + non-ionic surfactant	1 ppm	0.006nm

[0112]

[Table 5]

Table 5	Type of cleaning liquid	Extraneous matter defect evaluation (counted number)
Example 1	TMAH	831
Example 2	TMAH + DBS	352
Example 3	TMAH + DBS	401
Example 4	TMAH + DBS	380
Example 5	TMAH + DBS	366
Example 6	TMAH + non-ionic surfactant	364

10

[0113]

The following facts were found from the results shown in Tables 3 and 5

given above.

1. According to the present invention, it is possible to suppress the increase in the surface roughness of the substrate after being subjected to the cleaning processing. In the case of using TMAH, the value of ΔRa becomes
5 smaller than in the case of using KOH and NaOH which are conventionally used.

2. According to the examples of the present invention, the same cleaning performance as that obtained in the case of using KOH and NaOH which are conventionally used is obtained, and the increase in the surface roughness of the substrate after being subjected to the cleaning processing can be suppressed to a
10 very small level. The results of Table 4 indicates that the value of ΔRa becomes smaller as the concentration of alkali metal ions is changed to less than 200 ppm, 100 ppm or less, 10 ppm or less, and 1 ppm or less in this order. In addition, as can be seen from the results of Table 5, particularly, addition of the surfactant DBS reduces the number of extraneous matter defects almost by half, and it is therefore
15 preferable to add DBS. Even the number of extraneous matter defects counted in Example 1 is a level enough for use as a magnetic disk glass substrate.

3. In contrast, when cleaning is performed by using KOH and NaOH which are conventionally used, good cleaning performance can be obtained, but the increase in the surface roughness of the substrate after being subjected to the
20 cleaning processing is large.

[0114]

(Manufacturing of magnetic disk)

A magnetic disk for perpendicular magnetic recording was manufactured by performing the following film forming step on the magnetic disk glass substrate
25 obtained in Example 1 described above.

Specifically, an adhesive layer in the form of a CrTi-based alloy thin film, a soft magnetic layer in the form of a CoTaZr alloy thin film, a seed layer made of NiW, an underlayer in the form of a Ru thin film, a perpendicular magnetic recording layer in the form of a CoCrPt-based alloy thin film, a carbon protective

layer, and a lubricating layer were formed in a sequential manner on the glass substrate. The protective layer is to prevent degradation of the magnetic recording layer caused by contact with a magnetic head. The protective layer is composed of hydrogenated carbon and yields wear resistance. The lubricating
5 layer was formed by a dipping method using an alcohol-modified perfluoropolyether liquid lubricant.

The obtained magnetic disk was incorporated into a HDD equipped with a DFH head, and then subjected to load/unload durability testing for one month while causing the DFH function to operate in a high temperature and high humidity
10 environment at a temperature of 80°C and a humidity of 80%RH. As a result, there was no particular trouble, and good results were obtained.

Description of Reference Signs

[0115]	1	Glass Substrate
15	2	Sun Gear
	3	Internal Gear
	4	Carrier
	5	Upper Surface Plate
	6	Lower Surface Plate
20	7	Polishing Pad
	11	Main Surface of Substrate
	12, 13	End Face of Substrate

CLAIMS

1. A method for manufacturing a glass substrate for a magnetic disk comprising glass substrate cleaning processing,
wherein the glass substrate contains at least one component of sodium
5 and potassium in a glass component; and
cleaning processing is performed on a plurality of the glass substrates having a main surface polished into a mirror-finished surface by using a cleaning liquid containing an alkaline agent that is free of sodium and potassium, and maintaining a condition in which a total concentration of sodium ions and
10 potassium ions in the cleaning liquid is 4.00×10^{-3} mol/L or less.
2. The method for manufacturing a glass substrate for a magnetic disk according to claim 1, wherein the mirror-finished surface refers to the main surface of the glass substrate having a surface roughness Ra of 0.15 nm or less.
15
3. The method for manufacturing a glass substrate for a magnetic disk according to claim 1 or 2, wherein a difference between the surface roughness (Ra) of the main surface of the glass substrate after being subjected to the cleaning processing and the surface roughness (Ra) of the main surface of the
20 glass substrate immediately before being subjected to the cleaning processing is within 0.06 nm.
4. The method for manufacturing a glass substrate for a magnetic disk according to any one of claims 1 to 3, wherein a total concentration of sodium ions
25 and potassium ions in the cleaning liquid is 2.00×10^{-3} mol/L or less.
5. The method for manufacturing a glass substrate for a magnetic disk according to any one of claims 1 to 4, wherein the alkaline agent is tetraalkyl ammonium hydroxide.
30
6. The method for manufacturing a glass substrate for a magnetic disk according to any one of claims 1 to 5, wherein the cleaning liquid further contains

a surfactant that is free of sodium and potassium.

7. The method for manufacturing a glass substrate for a magnetic disk according to any one of claims 1 to 6, wherein glass constituting the glass
5 substrate is aluminosilicate glass containing at least one of Na_2O and K_2O .

8. A method for manufacturing a glass substrate for a magnetic disk comprising glass substrate cleaning processing,
wherein a relationship between an amount of increase in surface
10 roughness (Ra) of a main surface of the glass substrate after being subjected to the cleaning processing with respect to that before being subjected to the cleaning processing and a total concentration of sodium ions and potassium ions in a cleaning liquid used in the cleaning processing is obtained in advance,
the total concentration of sodium ions and potassium ions in the cleaning
15 liquid is determined based on the obtained relationship such that the amount of increase in the surface roughness (Ra) is 0.06 nm or less, and
the cleaning processing is performed on the glass substrate having a main surface polished into a mirror-finished surface by maintaining a condition in which the total concentration of sodium ions and potassium ions in the cleaning liquid is
20 less than or equal to the determined concentration.

9. A method for manufacturing a glass substrate for a magnetic disk comprising glass substrate cleaning processing,
wherein the glass substrate contains at least one component of sodium
25 and potassium in a glass component, and
cleaning processing is performed on the glass substrate having a main surface polished into a mirror-finished surface by using a cleaning liquid containing an alkaline agent that is free of sodium and potassium, and performing replacement of the cleaning liquid if a total concentration of sodium ions and
30 potassium ions in the cleaning liquid exceeds 4.00×10^{-3} mol/L.

10. A method for manufacturing a glass substrate for a magnetic disk

comprising glass substrate cleaning processing,

wherein the cleaning processing comprises processing of bringing the glass substrate into contact with a cleaning liquid containing tetramethyl ammonium ions, and

5 the cleaning processing is performed while suppressing a total amount of sodium ions and potassium ions in the cleaning liquid to less than 200 ppm.

11. The method for manufacturing a glass substrate for a magnetic disk according to claim 10, wherein the glass substrate contains at least one
10 component of sodium and potassium in a glass component.

12. The method for manufacturing a glass substrate for a magnetic disk according to claim 10 or 11, wherein the cleaning liquid further contains at least one substance of a surfactant, a chelating agent and a dispersing agent, and
15 the cleaning processing is performed while suppressing the total amount of sodium ions and potassium ions in the cleaning liquid to less than 200 ppm.

13. The method for manufacturing a glass substrate for a magnetic disk according to any one of claims 10 to 12, wherein a difference between surface
20 roughness (Ra) of a main surface of the glass substrate after being subjected to the cleaning processing and the surface roughness (Ra) of the main surface of the glass substrate immediately before being subjected to the cleaning processing is within 0.06 nm.

25 14. The method for manufacturing a glass substrate for a magnetic disk according to any one of claims 10 to 13, wherein the surface roughness (Ra) of the main surface of the glass substrate immediately before being subjected to the cleaning processing is 0.13 nm or less.

30 15. The method for manufacturing a glass substrate for a magnetic disk according to any one of claims 10 to 14, wherein the cleaning liquid has a pH of 10 or more.

16. The method for manufacturing a glass substrate for a magnetic disk according to any one of claims 10 to 15, wherein the cleaning processing is cleaning processing that is performed after a final polishing step among polishing
5 steps of polishing the main surface of the glass substrate by using polishing abrasive grains.

17. A cleaning liquid for cleaning a glass substrate for a magnetic disk, which is used in cleaning processing for cleaning the glass substrate for a
10 magnetic disk,

wherein the cleaning liquid contains at least tetramethyl ammonium hydroxide and a surfactant that is free of sodium and potassium.

18. A method for manufacturing a magnetic disk, comprising forming at
15 least a magnetic recording layer on the glass substrate for a magnetic disk obtained by the method for manufacturing a glass substrate for a magnetic disk according to any one of claims 1 to 16.