

DESCRIPTION

Title of Invention:

METHOD FOR MANUFACTURING GLASS SUBSTRATE FOR MAGNETIC
DISK, AND METHOD FOR MANUFACTURING MAGNETIC DISK

5

Technical Field

[0001]

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

Background Art

[0002]

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

[0003]

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

A method as disclosed in Patent Literature 1 in which a substrate is washed with a cleaning liquid obtained by dissolving an inorganic alkaline agent such as NaOH or KOH in water after polishing is a common conventional method, for example.

Prior Art Document(s)

Patent Literature

[0004]

Patent Literature 1: JP 2010-86563 A

Summary of Invention

Problem to be Solved by the Invention

[0005]

Current HDDs can achieve a recording density as high as about 500 gigabits per square inch, and it is possible to store about 320 gigabytes of information on a 2.5-inch (65-mm-diameter) magnetic disk, for example, but there has been demand to achieve higher recording densities such as 375 to 500 gigabytes and 1 terabyte. With such recent demand for HDDs with a larger storage capacity, requirement of improving the substrate surface quality has become more strict than ever. In a next-generation substrate to be used for a

375- to 500-gigabyte magnetic disk as described above, for example, the substrate largely affects media characteristics, and therefore, there is demand to further improve current products in terms of not only the roughness of the substrate surface, but also in terms of surface defects caused by the adhesion of foreign matter not being present.

[0006]

The reason why next-generation substrates significantly affect media characteristics is as follows.

A large reduction in the flying height of a magnetic head (a gap between the magnetic head and the surface of a medium (magnetic disk)) can be given as an example. In this manner, the magnetic head and the magnetic layer of the medium come close to each other, and therefore, it becomes possible to pick up signals of smaller magnetic particles and thus to attain a high recording density. In recent years, to achieve a flying height that is lower than ever, the magnetic head has been provided with a function called dynamic flying height (DFH). This is a function of causing only a recording and reproducing element of the magnetic head and its surroundings to project toward a medium surface by providing a heating unit such as an extremely small heater near the recording and reproducing element. It is considered that in the future, with this DFH function, the gap between the element of the magnetic head and the medium surface will be reduced to an extremely low level such as less than 2 nm or less than 1 nm. Under these 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 minuscule projection formed by the adhesion of very fine foreign matter (with a length in an in-plane direction of the main surface of about 10 to 40 nm at minimum, for example) that was previously not a problem, the risk of collision of the magnetic head increases because the projection remains on the medium surface as a defect.

[0007]

Incidentally, investigations conducted by the inventors of the present invention 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 even by
5 using various conventional precision polishing techniques and precision cleaning techniques including the technique disclosed in Patent Literature 1 above, or even by using these techniques in combination.

Requirement for improvement in the substrate surface quality associated with the recent demand for HDDs with a larger storage capacity has become
10 more strict than ever. Regarding the level of smoothness required for the substrate surface, Ra of about 0.3 to 0.4 nm was used until several years ago, for example, but nowadays, Ra of about 0.1 to 0.2 nm is used. That is, magnetic-disk glass substrates are required to have a smoothness at a level that is significantly different from the level required several years ago, and it is
15 expected that the requirement level will become higher in the future. The level required several years ago can somehow be attained even with a conventional alkaline cleaning method using the inorganic alkaline agent, but it is difficult to attain at least the current required level with the conventional method. In short, under these circumstances, there is a limit to achieving further improvement in
20 the substrate surface quality by using conventional improvement methods. It should be noted that the alkaline agent here refers to a substance that is alkaline when dissolved in water.

[0008]

The present invention has been made to solve the problems
25 encountered with the conventional techniques, and a first object thereof is to provide a method for manufacturing a magnetic-disk glass substrate in which cleaning processing can be performed while causing as little deterioration of a highly smooth surface state obtained through precision polishing as possible,

and as a result, an ultra-low roughness (a high level of smoothness) can be achieved. A second object is to provide a method for manufacturing a magnetic-disk glass substrate in which cleaning that provides a high level of cleanliness can be carried out while a high level of smoothness obtained through
5 precision polishing is maintained.

Means to Solve the Problem

[0009]

In order to increase the level of cleanliness of the substrate, fine foreign
10 matter that has firmly adhered to the substrate surface at a level that was previously not a problem needs to be removed by cleaning. For this reason, it is preferable to perform cleaning by using an alkaline chemical solution having a high pH (strong alkalinity) because a high level of cleanliness can be achieved. This is because the glass surface is strongly etched by the alkaline chemical
15 solution having a high pH, and thus even the foreign matter firmly adhering to the surface can be completely removed. However, with the conventional alkaline cleaning using an inorganic alkaline agent such as NaOH or KOH, the etching effect with respect to glass increases as the pH increases, whereas the surface roughness of the substrate increases due to the cleaning. Therefore, it is not
20 possible to maintain an ultra-smooth surface obtained through precision polishing. The level of surface roughness required several years ago can somehow be attained even with the conventional alkaline cleaning method using the inorganic alkaline agent, but it is difficult to attain at least a current required level of surface roughness, which is much more strict than the level required
25 several years ago, with the conventional method.

[0010]

Therefore, the inventors of the present invention attempted various approaches to a method for suppressing an increase in the surface roughness of

the substrate while the cleaning power obtained by alkaline cleaning is maintained. The inventors of the present invention examined the application of an organic alkaline agent, for example. However, even when the organic alkaline agent was used, the surface roughening was sometimes significant and sometimes insignificant depending on the type of the agent. Moreover, it was revealed that even when the same type of organic alkaline agent was used, a degree of the surface roughening after cleaning varied depending on the production lot.

Conventionally, it has commonly been thought that the increase in the glass substrate surface roughness after alkaline cleaning largely depends on the strength of alkalinity (pH) of a cleaning liquid due to the addition of the alkaline agent, in that the stronger the alkalinity of the cleaning liquid is, the more the roughness increases. However, as a result of intensive research on this point, the inventors of the present invention found that sodium ions and potassium ions in the cleaning liquid were largely responsible for the increase in glass substrate roughness during alkaline cleaning. Furthermore, they found that the variation in the degree of surface roughening after cleaning depending on the type of the organic alkaline agent and the production lot was affected by the difference in the content of sodium ions and potassium ions in the cleaning liquid. For example, an organic alkali such as tetramethylammonium hydroxide (TMAH) originally contains neither sodium ions nor potassium ions, but it is thought that sodium, potassium and the like are inevitably mixed into the organic alkali during the industrial manufacturing process. The inventors found that this mixing was responsible for the surface roughening of the glass substrate.

[0011]

As a result, the inventors of the present invention found that the increase in the glass substrate surface roughness after cleaning could be suppressed by performing cleaning while suppressing the content of sodium ions and

potassium ions in the cleaning liquid such that the content did not exceed a predetermined value, for example.

In addition, they also found that a specific organic alkaline agent was preferable as the alkaline agent to be used in cleaning.

5 [0012]

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

That is, the present invention includes the following aspects.

(Aspect 1)

10 An aspect of the present invention is a method for manufacturing a magnetic-disk glass substrate including performing cleaning processing in which a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline cleaning liquid and cleaned, wherein a glass composition of the glass substrate includes at least one of sodium and
15 potassium, the cleaning liquid used in the cleaning processing contains an organic alkali represented by General Formula I below, and the cleaning processing is performed while a content of sodium ions and potassium ions in the cleaning liquid is suppressed.

General Formula I

20 $[(R)_4N]^+OH^-$

(It should be noted that R represents an alkyl group, and at least one of the four alkyl groups binding to the N atom has at least one hydroxyl group (OH group)).

[0013]

25 (Aspect 2)

In the method for manufacturing a magnetic-disk glass substrate according to aspect 1, at least one of four Rs binding to the N atom in the organic alkali is a linear alkyl group having a hydroxyl group at a terminus that

does not bind to the N atom.

(Aspect 3)

In the method for manufacturing a magnetic-disk glass substrate according to aspect 2, the linear alkyl group having a hydroxyl group at a terminus that does not bind to the N atom in the organic alkali has two or more carbon atoms between the N atom and the hydroxyl group.

[0014]

(Aspect 4)

In the method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 3, the cleaning processing is performed while a total amount of sodium ions and potassium ions in the cleaning liquid is suppressed to 4 millimole/L or less.

[0015]

(Aspect 5)

Another aspect of the present invention is a method for manufacturing a magnetic-disk glass substrate including performing cleaning processing in which a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline cleaning liquid and cleaned, wherein a glass composition of the glass substrate includes at least one of sodium and potassium, the cleaning liquid used in the cleaning processing contains an organic alkali represented by General Formula I below, and the cleaning processing is performed under a condition that a total amount of sodium ions and potassium ions in the cleaning liquid is 4 millimole/L or less.

General Formula I

$[(R)_4N]^+OH^-$

(It should be noted that R represents an alkyl group, and at least one of the four alkyl groups binding to the N atom has at least one hydroxyl group (OH group)).

[0016]

(Aspect 6)

Another aspect of the present invention is a method for manufacturing a magnetic-disk glass substrate including performing cleaning processing in which
 5 a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline cleaning liquid and cleaned, wherein a glass composition of the glass substrate includes at least one of sodium and potassium, the cleaning liquid used in the cleaning processing contains an organic alkali represented by General Formula I below, and a relationship
 10 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 surface roughness (Ra) before the cleaning processing and a total amount of sodium ions and potassium ions in the cleaning liquid is obtained in advance, the total amount of sodium ions and potassium ions in the cleaning liquid is
 15 determined based on the obtained relationship such that the amount of increase in the surface roughness (Ra) is 0.05 nm or less, and the cleaning processing is performed while a condition that the total amount of sodium ions and potassium ions in the cleaning liquid is less than or equal to the determined total amount is maintained.

20 General Formula I



(It should be noted that R represents an alkyl group, and at least one of the four alkyl groups binding to the N atom has at least one hydroxyl group (OH group)).

25 [0017]

(Aspect 7)

In the method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 6, the cleaning liquid further contains at least

one selected from N,N'-tetramethylethylenediamine and derivatives of N,N'-tetramethylethylenediamine.

[0018]

(Aspect 8)

5 Another aspect of the present invention is a method for manufacturing a magnetic-disk glass substrate including performing cleaning processing in which a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline cleaning liquid and cleaned, wherein a glass composition of the glass substrate includes at least one of sodium and
10 potassium, the cleaning liquid used in the cleaning processing contains at least one alkaline agent selected from tetramethylammonium hydroxide, N,N'-tetramethylethylenediamine, and derivatives of N,N'-tetramethylethylenediamine, and in order to reduce roughening of the glass substrate surface caused by the cleaning processing, the cleaning processing is
15 performed while a content of sodium ions and potassium ions in the cleaning liquid used in the cleaning processing is suppressed.

[0019]

(Aspect 9)

In the method for manufacturing a magnetic-disk glass substrate
20 according to aspect 8, the cleaning processing is performed while a total amount of sodium ions and potassium ions in the cleaning liquid is suppressed to 4 millimole/L or less.

[0020]

(Aspect 10)

25 Another aspect of the present invention is a method for manufacturing a magnetic-disk glass substrate including performing cleaning processing in which a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline cleaning liquid and cleaned, wherein a glass

composition of the glass substrate includes at least one of sodium and potassium, the cleaning liquid used in the cleaning processing contains at least one alkaline agent selected from tetramethylammonium hydroxide, N,N'-tetramethylethylenediamine, and derivatives of

- 5 N,N'-tetramethylethylenediamine, and the cleaning processing is performed under a condition that a total amount of sodium ions and potassium ions in the cleaning liquid is 4 millimole/L or less.

[0021]

(Aspect 11)

- 10 Another aspect of the present invention is a method for manufacturing a magnetic-disk glass substrate including performing cleaning processing in which a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline cleaning liquid and cleaned, wherein a glass composition of the glass substrate includes at least one of sodium and
- 15 potassium, the cleaning liquid used in the cleaning processing contains at least one alkaline agent selected from tetramethylammonium hydroxide, N,N'-tetramethylethylenediamine, and derivatives of N,N'-tetramethylethylenediamine, and a relationship between an amount of increase in surface roughness (Ra) of a main surface of the glass substrate after
- 20 being subjected to the cleaning processing with respect to surface roughness (Ra) before the cleaning processing and a total amount of sodium ions and potassium ions in the cleaning liquid is obtained in advance, the total amount 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
- 25 roughness (Ra) is 0.05 nm or less, and the cleaning processing is performed while a condition that the total amount of sodium ions and potassium ions in the cleaning liquid is less than or equal to the determined total amount is maintained.

[0022]

(Aspect 12)

In the method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 5 and 7 to 10, a difference between surface roughness (Ra) of a main surface of the glass substrate after being subjected to the cleaning processing and surface roughness (Ra) of a main surface of the glass substrate just before being subjected to the cleaning processing is 0.05 nm or less.

(Aspect 13)

In the method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 12, the cleaning processing is performed after polishing processing in which a main surface of the glass substrate is polished using a polishing liquid that contains colloidal silica abrasive particles and is adjusted so as to be in an acidic range.

[0023]

(Aspect 14)

Yet another aspect of the present invention is a method for manufacturing a magnetic disk including forming at least a magnetic recording layer on the magnetic-disk glass substrate manufactured with the method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 13.

Effect of the Invention

[0024]

With the present invention, it is possible to provide a method for manufacturing a magnetic-disk glass substrate in which cleaning processing can be performed while causing as little deterioration of a highly smooth surface state obtained through precision polishing as possible, and as a result, an

ultra-low roughness (a high level of smoothness) can be achieved. Moreover, with the present invention, it is possible to provide a method for manufacturing a magnetic-disk glass substrate in which cleaning that provides a high level of cleanliness can be carried out while a high level of smoothness obtained through precision polishing is maintained. With the present invention as described above, it is possible to manufacture high-quality magnetic-disk glass substrates that achieve a much greater reduction in the surface roughness of the main surface of the substrates than ever and a reduction of surface defects caused by the adhesion of foreign matter or the like compared with conventional substrates.

The magnetic disk glass substrate obtained by the present invention can be favorably used as, in particular, a current magnetic-disk glass substrate required to meet substrate surface quality requirements that are even more strict than several years ago. In addition, it is possible to use the glass substrate obtained by the present invention to obtain a highly reliable magnetic disk that can perform a stable operation for a long period of time even when combined with a magnetic head provided with the DFH function and designed to have a very low amount of flying height.

Brief Description of Drawings

[0025]

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.

Description of Embodiment

[0026]

Hereinafter, embodiments of the present invention will be described in detail.

A magnetic-disk glass substrate is usually manufactured through grinding processing, main surface polishing processing, chemical strengthening processing, and the like.

[0027]

5 In the manufacturing of the magnetic disk glass substrate, first, molten glass is molded into a disk-shaped glass substrate (glass disk) by direct pressing. It should be noted that 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 having a
10 predetermined size. Next, 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 apparatus is used, and the main surfaces of the glass substrate are ground using hard abrasive particles such as those of diamond. By grinding the main surfaces of the glass substrate in this
15 manner, the substrate is processed so as to have a predetermined thickness and flatness and attain a predetermined surface roughness.

[0028]

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

[0029]

25 The polishing liquid used in the polishing processing is basically made of a combination of an abrasive and water as a solvent, and optionally contains a pH adjusting agent for adjusting the pH of the polishing liquid, and other additives.

[0030]

It is preferable to perform polishing using colloidal silica abrasive particles particularly in final polishing in order to reduce roughness. From the viewpoint of polishing efficiency, it is preferable to use the colloidal silica
5 abrasive particles contained in the polishing liquid that have an average particle diameter of about 10 to 100 nm. In particular, in the present invention, as the abrasive particles contained in the polishing liquid to be used in the final polishing processing (second polishing processing in a latter stage, which will be described later), it is preferable to use abrasive particles having an average
10 particle diameter of about 10 to 40 nm, and it is particularly preferable to use fine abrasive particles having an average particle diameter of about 10 to 20 nm, from the viewpoint of further reducing the surface roughness. However, the finer the abrasive particles are, the more difficult to remove they are once they adsorb to the glass substrate. In particular, since colloidal silica has a
15 composition similar to that of the glass substrate, the colloidal silica is likely to firmly adsorb to the glass substrate. The cleaning processing of the present invention is particularly effective when performed after the polishing using ultra-fine colloidal silica abrasive particles having an average particle diameter of 20 nm or less, because it is possible to remove the abrasive particles by
20 cleaning while extremely low surface roughness is maintained, and to make the glass substrate surface clean.

It should be noted that in the present invention, the above-mentioned average particle diameter denotes a particle diameter at which a cumulative curve reaches 50% when the cumulative curve is determined by setting the total
25 volume of powder particles in the particle size distribution measured by a light scattering method to 100% (referred to as "cumulative average particle diameter (50% diameter)" hereinafter). In the present invention, specifically, the cumulative average particle diameter (50% diameter) is a value obtained by

measuring the particle diameter using a particle diameter/particle size distribution measurement apparatus.

[0031]

As the colloidal silica abrasive particles used in the present invention, it is possible to use colloidal silica abrasive particles produced by hydrolysis of an organosilicon compound. Since such abrasive particles are not likely to aggregate with one another and are not likely to form coarse particles, it is possible to suppress the roughness of the glass substrate surface subjected to the polishing processing to an extremely low level and to significantly reduce the number of scratches thereon. However, such abrasive particles are more likely to firmly adhere to the glass substrate surface subjected to the polishing processing than colloidal silica abrasive particles obtained by performing an ion exchange process on water glass. Therefore, by performing the cleaning processing according to the present invention, it is possible to remove the abrasive particles by cleaning while extremely low surface roughness is maintained, and to make the glass substrate surface clean.

[0032]

In the present invention, there is no particular limitation on the polishing method performed in the polishing processing, but it is sufficient that the glass substrate is brought into contact with a polishing pad, the polishing pad and the glass substrate are moved relative to each other while a polishing liquid containing abrasive particles is supplied, and the glass substrate surface is thereby polished to a mirror-finished surface, for example. A planetary gear-type double-side polishing apparatus can be preferably used, for example.

[0033]

It is particularly preferable to use a polishing pad (suede pad) of a soft polisher as the polishing pad in the final polishing. It is preferable to set the hardness of the polishing pad to be 60 or more and 80 or less in Asker C

hardness. It is preferable that the surface of the polishing pad that is brought into contact with the glass substrate is made of resin foam having open foam pores, specifically polyurethane foam. By polishing the glass substrate in this manner, the glass substrate surface can be polished to a smooth mirror-finished surface.

[0034]

(First Embodiment)

According to a first embodiment of the present invention, as described in aspect 1 above, in the cleaning processing, which is performed after mirror-polishing processing performed on a main surface of a glass substrate, in order to reduce the surface roughening of the glass substrate due to the cleaning processing, a cleaning liquid used in the cleaning processing contains a specific organic alkali, and the cleaning processing is performed while the content of sodium ions and potassium ions in the cleaning liquid is suppressed.

[0035]

Conventionally, it has commonly been thought that the increase in the glass substrate surface roughness after alkaline cleaning largely depends on the pH of a cleaning liquid, in that the stronger the alkalinity of the cleaning liquid is, the more the roughness increases. However, the inventors of the present invention found that not only the alkalinity of the alkaline agent used in cleaning but also the type of positive ion paired with OH ion have a great influence on the amount of increase in the roughness.

[0036]

For example, when a strong alkali such as NaOH or KOH is used as the alkaline agent, it is possible to obtain a foreign matter removing effect obtained through a good etching effect, but the glass substrate surface roughness after cleaning significantly increases. The investigations conducted by the inventors of the present invention have revealed that, in this case, not only the alkalinity of

the alkaline agent but also the presence of positive ions such as sodium ions and potassium ions is also significantly responsible for the increase in the roughness of the substrate.

[0037]

5 Therefore, the inventors of the present invention found that it was preferable to perform the cleaning processing under the condition that the content (total amount) of sodium ions and potassium ions in the cleaning liquid was suppressed particularly to 4 millimoles (expressed as "mmol" hereinafter) /L or less during the cleaning processing (or while this condition is maintained), that
10 is, to perform the cleaning processing under the condition that the total amount thereof was 4 mmol/L or less. Accordingly, the etching effect of the OH ions of the alkaline agent contained in the cleaning liquid can be obtained, and at the same time, by suppressing the content of sodium ions and potassium ions in the cleaning liquid, the increase in the roughness of the glass substrate can be
15 suppressed. It is particularly preferable to perform the cleaning processing while suppressing the content (total amount) of sodium ions and potassium ions in the cleaning liquid to 2 mmol/L or less, and more preferably to 1 mmol/L or less.

 In the present invention, it is preferable to suppress the content of
20 sodium ions and potassium ions in the cleaning liquid such that the main surface of the glass substrate subjected to the cleaning processing has a surface roughness Ra of 0.2 nm or less, for example.

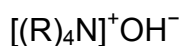
 It should be noted that the content of sodium ions and potassium ions in the cleaning liquid can be measured by ion chromatography or an ICP method,
25 for example, using the cleaning liquid sampled from the cleaning bath. If both the content of sodium ions and potassium ions in the cleaning liquid just before the cleaning processing and the content thereof after the cleaning processing are smaller than or equal to a predetermined value (4 mmol/L), it can be said

that this condition is maintained during the cleaning processing.

[0038]

The inventors of the present invention searched for a method for suppressing the content of sodium ions and potassium ions in the cleaning liquid and suppressing the increase in the surface roughness of the substrate while maintaining the cleaning power obtained by alkaline cleaning. As a result, they found that it was preferable to use a cleaning liquid containing a specific alkaline agent, namely an alkaline agent containing neither a sodium component nor a potassium component, and that an organic alkali (referred to as also "organic alkali I of the present invention" hereinafter) expressed by General Formula I below was particularly preferable.

General Formula I



(It should be noted that R represents an alkyl group, and at least one of the four alkyl groups binding to the N atom has at least one hydroxyl group (OH group)).

[0039]

In the present invention, it is preferable that at least one of four Rs binding to the N atom in the above-mentioned organic alkali I of the present invention is a linear alkyl group having a hydroxyl group at a terminus that does not bind to the N atom. In order to remove foreign matter attaching to the surface by cleaning while maintaining the smoothness of the surface without increasing the roughness thereof, it is effective that etching proceeds in only the outermost layer of glass, and it is necessary that etching does not excessively proceed in the other portion of the glass. To achieve this, it is preferable that the glass surface is covered with a substance having a high affinity with glass. Glass is covered with silanol (Si-OH) and negatively charged ionized species thereof (Si-O⁻), and a hydroxyl group included in a substance serving as the

organic alkali I of the present invention has an affinity with the former silanol via a hydrogen bond and has an effect of enhancing the adhesiveness with respect to glass due to a positive charge of a nitrogen atom and the ionized species of silanol. This is preferable because it is easy to obtain this effect when a
5 hydroxyl group exists at a terminus that does not bind to the N atom.

[0040]

In particular, it is preferable that the above R is a linear alkyl group having two or more carbon atoms between the N atom and the hydroxyl group. If the number of hydroxyl groups in the molecule increases, one molecule stays
10 on the glass surface for a longer period of time, resulting in higher cleaning power due to stronger affinity with the glass surface.

In this case, it is preferable that the number of carbon atoms between the N atom and the hydroxyl group is 6 or less. If the number of carbon atoms is more than 6, both the molecular weight and molecular size increase, so that
15 the diffusion during cleaning becomes slower, thus weakening the effect of covering the glass surface. Therefore, a risk of re-adhesion of foreign matter increases, thus deteriorating the cleaning effect.

[0041]

Specific preferable examples of the organic alkali I of the present
20 invention include quaternary ammonium hydroxides having a hydroxyl group, such as a choline hydroxide, bis(2-hydroxyethyl)dimethylammonium hydroxide, tris(2-hydroxyethyl)methylammonium hydroxide, (3-hydroxypropyl)trimethylammonium hydroxide, (4-hydroxybutyl)trimethylammonium hydroxide,
25 (6-hydroxyhexyl)trimethylammonium hydroxide, and (7-hydroxyheptyl)trimethylammonium hydroxide. Of course, in the present invention, there is no limitation to these specific examples.

[0042]

The above-mentioned organic alkali I of the present invention has a high degree of solubility in water, and is strongly alkaline when dissolved in water.

Although the organic alkali I has a great foreign matter removing effect obtained through the etching effect with respect to glass, the surface roughening due to etching can be suppressed. This mechanism is not clearly known, but may be explained as follows.

Specifically, when potassium ions and sodium ions bind 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, the etching rate of the binding portions is selectively enhanced, and therefore, the etching rate on the glass substrate surface varies, which is thought to cause an increase in the surface roughness. However, it is thought that even when the above-mentioned organic alkali I of the present invention binds to OH groups on the glass surface, the etching rate does not increase. Moreover, it is thought that since the above-mentioned organic alkali I of the present invention binds to the OH groups on the glass substrate surface in advance, an effect of suppressing binding of sodium ions and potassium ions eluted thereafter from the glass substrate during the cleaning processing, for example, to the OH groups is exhibited. Accordingly, by performing the cleaning processing by using a cleaning liquid containing the above-mentioned organic alkali I of the present invention while suppressing the content of sodium ions and potassium ions in the cleaning liquid, the increase in the surface roughness of the substrate after cleaning can be suppressed. In short, since the organic alkali I of the present invention has a strong adsorbing effect with respect to the surface of silica, the organic alkali I adsorbs to the glass substrate and the surfaces of silica abrasive particles to prevent them from firmly adhering to each other and to prevent sodium ions and potassium ions in the cleaning liquid from binding to the glass substrate surface, and thus the increase in the surface roughness is

prevented. Therefore, an ultra-low surface roughness (a high level of smoothness) can be achieved in the glass substrate after cleaning, a good cleaning effect can be obtained, and a high level of cleanliness can be achieved. [0043]

5 Although there is no particular limitation on the pH of the cleaning liquid as long as the cleaning liquid is alkaline, the pH of the cleaning liquid is preferably 10 or more, and more preferably 11 or more. If the pH is less than 10, the etching rate decreases, and therefore, it may take time to obtain the foreign matter removing effect obtained through the etching effect with respect to glass,
10 and the productivity may deteriorate. On the other hand, if the pH is more than 13, a sufficient alkaline cleaning effect can be obtained, but the etching rate of the alkali increases. Therefore, when the glass composition includes sodium and potassium, the amounts of sodium and potassium eluted therefrom increase, and it may become necessary to frequently perform an adjustment operation of
15 adjusting sodium ions and potassium ions in the cleaning liquid. In addition, the alkalinity becomes too strong, and thus care needs to be taken in handling the cleaning liquid.

[0044]

 Although there is no particular limitation on the content of the organic
20 alkali I of the present invention in the cleaning liquid, it is preferable that the content of the organic alkali I is in a range of 0.00001 to 1 mol/L, for example. If the content of the organic alkali I of the present invention is less than 0.00001 mol/L, the etching rate decreases, and thus it may take time to obtain the foreign matter removing effect obtained through the etching effect with respect to glass,
25 and the productivity may deteriorate. On the other hand, if the content of the organic alkali I of the present invention is more than 1 mol/L, a sufficient alkaline cleaning effect can be obtained, but the etching rate of the alkali increases. Therefore, when the glass composition includes sodium and potassium, the

amounts of sodium and potassium eluted therefrom increase, and it may become necessary to frequently perform an adjustment operation of adjusting sodium ions and potassium ions in the cleaning liquid. In addition, the alkalinity becomes too strong, and thus care needs to be taken in handling the cleaning liquid.

[0045]

In the case of reusing the cleaning liquid, if the content of sodium ions and potassium ions gradually increases due to the elution from the glass substrate, it is effective to add a chelating agent or the like for capturing alkali metal ions. The addition of the chelating agent makes it possible to prolong the life of the cleaning liquid to reduce the manufacturing cost. Examples of the chelating agent include N,N'-tetramethylethylenediamine and derivatives of N,N'-tetramethylethylenediamine. These substances have a chelating effect with respect to sodium ions and potassium ions, thus making it possible to prevent sodium ions and potassium ions from binding to the glass substrate surface and to prevent the increase in surface roughness. It should be noted that the above-mentioned substances are preferable as an alkaline agent for a cleaning liquid used in the cleaning processing of the present invention, which will be specifically described later.

[0046]

Incidentally, from the viewpoint of protecting the glass substrate surface during the cleaning processing by means of the organic alkali I of the present invention binding to the surface, the organic alkali I of the present invention such as the above-mentioned quaternary ammonium hydroxide having a hydroxyl group, e.g., a choline hydroxide, can bind to not only a silane hydroxide (ionized silanol) but also non-ionized silanol via the hydroxyl group, and exhibits a greater effect than quaternary ammonium hydroxides having no hydroxyl groups (e.g., the above-mentioned TMAH). Therefore, the organic alkali I sufficiently

exhibits such an effect at a low concentration.

[0047]

In spite of using an alkaline agent (e.g., the above-mentioned organic alkali I of the present invention) containing neither a sodium component nor a potassium component as mentioned above, the content of sodium ions and potassium ions in the cleaning liquid may gradually increase due to the elution from the glass substrate in the case of reusing the cleaning liquid. An example of a method for suppressing or controlling the content of sodium ions and potassium ions in the cleaning liquid is as follows. The cleaning liquid is sampled at the start of cleaning and at a predetermined timing during cleaning, for example, and the content of these ions in the cleaning liquid is measured. If the content of these ions may exceed a predetermined value, the content can be adjusted by being reduced by means of addition of a chelating agent or the like for capturing the above-mentioned ions, dilution with water, exchange of the cleaning liquid, and the like. Moreover, if the components of the glass substrate include Na and K, a relationship between a cleaning time or the number of batches (the number of instances of the cleaning processing) and the concentrations of sodium ions and potassium ions in the cleaning liquid may be found in advance, and processing for adjusting the content of sodium ions and potassium ions based on the found relationship may be performed.

[0048]

In the present invention, when a glass substrate having glass components including alkali metal components such as sodium and potassium is cleaned, it is preferable to perform the cleaning processing while suppressing the content of sodium ions and potassium ions in the cleaning liquid including the amounts of sodium ions and potassium ions due to the elution of the glass components into the alkali cleaning liquid to 4 mmol/L or less.

[0049]

Another embodiment related to the first embodiment of the present invention is a method for manufacturing a magnetic-disk glass substrate including performing cleaning processing in which a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline
5 cleaning liquid and cleaned, wherein a glass composition of the glass substrate includes at least one of sodium and potassium, the cleaning liquid used in the cleaning processing contains an organic alkali represented by General Formula I above, and a relationship between an amount of increase in surface roughness (Ra) of a main surface of the glass substrate after being subjected to the
10 cleaning processing with respect to surface roughness (Ra) before the cleaning processing and a total amount of sodium ions and potassium ions in the cleaning liquid is obtained in advance, the total amount 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 0.05 nm or less,
15 and the cleaning processing is performed while a condition that the total amount of sodium ions and potassium ions in the cleaning liquid is less than or equal to the determined total amount is maintained.

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

[0050]

For the purpose of enhancing the cleaning effect by preventing foreign matter that was removed from the substrate surface by the cleaning effect of the organic alkali I of the present invention from adhering to the substrate surface
25 again, the cleaning liquid may further contain additives such as a surfactant, a chelating agent, and a dispersing agent as appropriate.

[0051]

Examples of the surfactant that can be preferably used in the present

invention include anionic surfactants such as a sodium alkyl sulfate ester, fatty acid sodium, and an alkylarylsulfonate salt, and nonionic surfactants such as polyoxyethylene alkyl ether and a derivative of polyoxyethylene. Examples of the chelating agent include an aminocarboxylic acid such as EDTA, and an organic acid such as citric acid. Examples of the dispersing agent include phosphate, sulfate, and a macromolecular dispersing agent. It should be noted that when the surfactant, the chelating agent, and the dispersing agent are added to the cleaning liquid, care needs to be taken so that the concentration of two types of ions, namely sodium ions and potassium ions, which cause the glass substrate surface roughening, is in the above-mentioned range (4 mmol/L or less). There is a possibility that these two types of positive ions are contained in the molecular structure of the additives or as impurities in the additives. Therefore, it is preferable that these additives do not contain the above-mentioned two types of ions at least in their molecular structure.

[0052]

Since these additives such as the surfactant, the chelating agent, and the dispersing agent are generally prepared as a potassium salt and a sodium salt, it is also preferable to perform the cleaning processing while suppressing the content of sodium ions and potassium ions in the cleaning liquid to 4 mmol/L or less, for example, in a case where the cleaning liquid contains these additives. It should be noted that in such a case, it is preferable to use quaternary ammonium salts of quaternary ammonium cations such as tetramethylammonium ions. When quaternary ammonium salts are used, the addition amount can be increased without increasing the amount of sodium ions and potassium ions. Moreover, if sodium and potassium are inevitably contained as impurities in the additives during the manufacturing process of the additives, it is preferable to use the additives subjected to purification processing using an ion-exchange resin or the like such that the amount of sodium ions and

potassium ions is reduced.

[0053]

The above-mentioned cleaning processing is usually performed by bringing the glass substrate subjected to polishing processing, for example, into
5 contact with (e.g., immersing the glass substrate in) a cleaning bath accommodating a cleaning liquid containing an alkaline agent (e.g., the above-mentioned organic alkali I of the present invention) 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
10 cleaning time and the like can be set as appropriate in view of the cleaning effect and the productivity.

[0054]

(Second Embodiment)

According to a second embodiment of the present invention, as
15 described in aspect 8 above, in the cleaning processing, which is performed after mirror-polishing processing performed on a main surface of the glass substrate, in order to reduce the surface roughening of the glass substrate caused by the cleaning processing, a cleaning liquid used in the cleaning processing contains at least one alkaline agent selected from
20 tetramethylammonium hydroxide, N,N'-tetramethylethylenediamine, and derivatives of N,N'-tetramethylethylenediamine, and the cleaning processing is performed while the content of sodium ions and potassium ions in the cleaning liquid used in the cleaning processing is suppressed.

[0055]

25 The inventors of the present invention searched for a method for suppressing the increase in the surface roughness of the substrate while maintaining the cleaning power obtained by alkaline cleaning. As a result, they found that it was also preferable to use an organic alkaline agent such as

tetramethylammonium hydroxide (abbreviated to "TMAH" hereinafter),
N,N'-tetramethylethylenediamine (abbreviated to "TMEDA" hereinafter), and a
derivative of TMEDA as a specific alkaline agent, namely an alkaline agent
containing neither a sodium component nor a potassium component, other than
5 the "organic alkali I of the present invention" used in the above first embodiment.

Here, the derivative of TMEDA refers to a derivative obtained by
replacing a methyl group of TMEDA with H (hydrogen) or an alkyl group,
polyethylenediamine (or oligoethylenediamine), and polyethyleneimine (or
oligoethyleneimine). Specific examples of the derivative of TMEDA include
10 N,N,N',N'',N''-pentamethyldiethylenetriamine and
tris[2-(dimethylamino)ethyl]amine.

[0056]

The above-mentioned organic alkaline agent (referred to as also
"organic alkali II of the present invention" hereinafter) such as TMEDA, a
15 derivative of TMEDA, or TMAH has a high degree of solubility in water, and is
strongly alkaline when dissolved in water. Although the organic alkali II has a
great foreign matter removing effect obtained through the etching effect with
respect to glass, the surface roughening due to etching can be suppressed.
This mechanism is not clearly known, but may be explained as follows.

20 Specifically, when potassium ions and sodium ions bind 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, the etching
rate of the binding portions is selectively enhanced, and therefore, the etching
rate on the glass substrate surface varies, which is thought to cause an increase
25 in the surface roughness. However, it is thought that even when the
above-mentioned organic alkaline agent binds to OH groups on the glass
surface, the etching rate does not increase. Moreover, it is thought that since
the above-mentioned organic alkaline agent of the present invention binds to the

OH groups on the glass substrate surface in advance, an effect of suppressing binding of sodium ions and potassium ions to the OH groups thereafter is exhibited. Accordingly, by performing the cleaning processing while suppressing the content of sodium ions and potassium ions in the cleaning liquid, the increase in the surface roughness of the substrate after cleaning can be suppressed. Therefore, an ultra-low surface roughness (a high level of smoothness) can be achieved in the glass substrate after cleaning, a good cleaning effect can be obtained, and a high level of cleanliness can be achieved. [0057]

Although there is no particular limitation on the pH of the cleaning liquid as long as the cleaning liquid is alkaline, the pH of the cleaning liquid is preferably 10 or more, and more preferably 11 or more. If the pH is less than 10, the etching rate decreases, and therefore it may take time to obtain the foreign matter removing effect obtained through the etching effect with respect to glass, and the productivity may deteriorate. On the other hand, if the pH is more than 13, a sufficient alkaline cleaning effect can be obtained, but the etching rate of the alkali increases. Therefore, when the glass composition includes sodium and potassium, the amounts of sodium and potassium eluted therefrom increase, and it may become necessary to frequently perform an adjustment operation of adjusting sodium ions and potassium ions in the cleaning liquid. Moreover, the inner diameter and the outer diameter of the substrate, which need to be strictly controlled, may vary and fall outside of a predetermined range. In addition, the alkalinity becomes too strong, and thus care needs to be taken in handling the cleaning liquid.

[0058]

Although there is no particular limitation on the content of the organic alkali II of the present invention in the cleaning liquid, it is preferable that the content of the organic alkali II is in a range of 0.00001 to 1 mol/L, for example.

If the content of the organic alkali II of the present invention is less than 0.00001 mol/L, the etching rate decreases, and thus it may take time to obtain the foreign matter removing effect obtained through the etching effect with respect to glass, and the productivity may deteriorate. On the other hand, if the content of the organic alkali II of the present invention is more than 1 mol/L, a sufficient alkaline cleaning effect can be obtained, but the etching rate of the alkali increases. Therefore, when the glass composition includes sodium and potassium, the amounts of sodium and potassium eluted therefrom increase, and it may become necessary to frequently perform an adjustment operation of adjusting sodium ions and potassium ions in the cleaning liquid. Moreover, the inner diameter and the outer diameter of the substrate, which need to be strictly controlled, may vary and fall outside of a predetermined range. In addition, the alkalinity becomes too strong, and thus care needs to be taken in handling the cleaning liquid.

15 [0059]

It is more effective that the above-mentioned alkaline agent has a chelating effect of capturing sodium ions and potassium ions, and TMEDA, which is an organic alkaline agent, is strongly alkaline when dissolved in water and has a chelating effect with respect to sodium ions and potassium ions in the cleaning liquid, for example. Since sodium ions and potassium ions are inhibited from coming close to the glass substrate surface by TMEDA coordinating with sodium ions and potassium ions to form chelates, the glass substrate surface roughening can be suppressed. When the cleaning liquid is reused to continuously clean the glass substrate containing Na and K, TMEDA coordinates with Na ions and potassium ions that are gradually eluted into the cleaning liquid to form chelates, thus making it possible to cause the cleaning liquid to exhibit an effect of suppressing an increase in surface roughness for a long period of time. Therefore, in terms of a lifecycle of the cleaning liquid,

TMEDA is more effective than TMAH. For the above reasons, it is more preferable to use an organic alkaline agent such as TMEDA having a chelating effect.

[0060]

5 Another embodiment related to the second embodiment of the present invention is a method for manufacturing a magnetic-disk glass substrate including performing cleaning processing in which a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline cleaning liquid and cleaned, wherein a glass composition of the glass substrate
10 includes at least one of sodium and potassium, the cleaning liquid used in the cleaning processing contains at least one alkaline agent selected from tetramethylammonium hydroxide, N,N'-tetramethylethylenediamine, and derivatives of N,N'-tetramethylethylenediamine, and a relationship between an amount of increase in surface roughness (Ra) of a main surface of the glass
15 substrate after being subjected to the cleaning processing with respect to surface roughness (Ra) before the cleaning processing and a total amount of sodium ions and potassium ions in the cleaning liquid is obtained in advance, the total amount of sodium ions and potassium ions in the cleaning liquid is determined based on the obtained relationship such that the amount of increase
20 in the surface roughness (Ra) is 0.05 nm or less, and the cleaning processing is performed while a condition that the total amount of sodium ions and potassium ions in the cleaning liquid is less than or equal to the determined total amount is maintained.

25 With 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 smaller than or equal to a predetermined value.

It should be noted that regarding constituent elements of the second embodiment to which configurations similar to those of constituent elements of

the above-described first embodiment can be applied, redundant description has been omitted herein.

[0061]

In the present invention, an embodiment in which the organic alkali I of
5 the present invention used in the above-mentioned first embodiment and
TMEDA or a derivative of TMEDA used in the above-mentioned second
embodiment are used in combination is also preferable. This makes it possible
to significantly improve a period of time when the cleaning liquid can be used to
continuously perform processing. It is inferred that this results from a
10 synergistic effect of an adsorption effect of the organic alkali I of the present
invention with respect to the surfaces of the glass substrate and silica abrasive
particles and a chelating effect of TMEDA or the like with respect to sodium ions
and potassium ions eluted from the glass substrate.

[0062]

15 With above Embodiments 1 and 2 of the present invention, it is possible
to set the amount of increase in the surface roughness (Ra) caused by the
cleaning processing, that is, a difference (ΔRa) between the surface roughness
(Ra) of the main surface of the glass substrate after the cleaning processing and
the surface roughness (Ra) of the main surface of the glass substrate just before
20 the cleaning processing, to 0.05 nm or less, more preferably 0.04 nm or less,
and still more preferably 0.03 nm or less.

Depending on the surface roughness after polishing, it is possible to set
the surface roughness (Ra) of the main surface of the glass substrate after the
cleaning processing to 0.2 nm or less, more preferably 0.18 nm or less, and still
25 more preferably 0.15 nm or less.

[0063]

Generally, the polishing processing is usually performed in two stages:
first polishing processing for removing blemishes and distortion remaining on the

substrate surface after the grinding processing as described above; and second polishing processing for finishing the surface roughness of the main surface of the glass substrate into a smooth mirror-finished surface while maintaining the flat surface obtained through the first polishing processing (it should be noted
5 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 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. In particular, it is
10 preferable to perform the cleaning processing of the present invention as cleaning processing performed after polishing processing in which the main surface of the glass substrate is polished using a polishing liquid that contains colloidal silica abrasive particles and is adjusted so as to be in an acidic range. When the glass substrate is polished in an acidic state, the adhering amount of
15 foreign matter after polishing can be reduced compared with a case where the glass substrate is polished in an alkaline state, but a portion of elements comes out of the glass substrate surface due to the leaching effect of the acid. Thereafter, when cleaning is performed using an alkaline cleaning liquid, the etching effect varies, and thus the glass substrate surface tends to roughen
20 significantly. Accordingly, glass substrates having a low surface roughness and a high level of cleanliness can be obtained by applying the present invention.
[0064]

In the present invention, it is preferable that the (type of) glass constituting the glass substrate is aluminosilicate glass. Amorphous
25 aluminosilicate glass is more preferable. 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%

or more and 75 wt% or less, Al_2O_3 in an amount of 5 wt% or more and 23 wt% or less, Li_2O in an amount of 3 wt% or more and 10 wt% or less, and Na_2O in an amount of 4 wt% or more and 13 wt% or less as main components.

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

[0065]

As a characteristic of next-generation substrates, heat resistance may be required. In this case, as heat resistant glass, it is preferable to use glass that contains SiO_2 in an amount of 50 to 75 mol%; Al_2O_3 in an amount of 0 to 6 mol%; BaO in an amount of 0 to 2 mol%; Li_2O in an amount of 0 to 3 mol%; ZnO in an amount of 0 to 5 mol%; Na_2O and K_2O in a total amount of 3 to 15 mol%; MgO , CaO , SrO and BaO in a total amount of 14 to 35 mol%; and ZrO_2 , TiO_2 , La_2O_3 , Y_2O_3 , Yb_2O_3 , Ta_2O_5 , Nb_2O_5 , and HfO_2 in a total amount of 2 to 9 mol%, and 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, for example.

[0066]

In the present invention, the surface of the glass substrate subjected to the above-mentioned polishing processing preferably has an arithmetic mean surface roughness R_a of 0.20 nm or less, particularly 0.15 nm or less, and even more particularly 0.10 nm or less. Furthermore, the maximum surface roughness R_{max} is preferably 2.0 nm or less, particularly 1.5 nm or less, and even more particularly 1.0 nm or less. It should be noted that R_a and R_{max} as

used in the present invention both denote roughnesses that are calculated in accordance with the Japanese Industrial Standards (JIS) B 0601 (1982).

From a practical viewpoint, the above-mentioned surface roughness in the present invention is preferably the surface roughness of a surface shape
5 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.

[0067]

In the present invention, it is preferable to perform chemical strengthening processing before or after the polishing processing. As a method
10 for the chemical strengthening processing, it is preferable to use a low-temperature ion-exchange method that performs ion exchange in a temperature range not exceeding the glass transition point, for example. The chemical strengthening processing is processing in which a glass substrate is brought into contact with a molten chemical strengthening salt so that an alkali
15 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, whereby 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
20 of the glass substrate. A glass substrate subjected to the chemical strengthening processing has excellent impact resistance, and therefore, it is particularly preferable to mount the glass substrate on an HDD for mobile use, for example. As the chemical strengthening salt, a molten salt of an alkali metal nitrate such as potassium nitrate or sodium nitrate can be preferably used.

25 [0068]

With the method for manufacturing a magnetic-disk glass substrate 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 edge

surface 12 and an inner circumferential edge surface 13 located between the main surfaces 11 is obtained. The outer circumferential edge surface 12 is constituted by a side wall surface 12a, and chamfered surfaces 12b located, on both sides of the side wall surface 12a, between the side wall surface 12a and the main surfaces. The inner circumferential edge surface 13 has the same shape.

[0069]

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 recording layer (magnetic layer) on the magnetic-disk glass substrate according to the present invention. A hexagonal-system CoCrPt-based or CoPt-based ferromagnetic alloy with a large anisotropic magnetic field can be used as a material of the magnetic layer. It is preferable to form the magnetic layer on the glass substrate by a sputtering method such as a DC magnetron sputtering method.

[0070]

A protecting layer, a lubricant layer, and the like may be formed on the magnetic recording layer. An amorphous carbon-based protecting layer is preferable as the protecting layer. As the lubricant layer, a lubricant that has a functional group at the terminal of the main chain of a perfluoropolyether compound can be used.

The magnetic disk glass substrate obtained according to the present invention can be used to provide a highly reliable magnetic disk.

25

Working Examples

[0071]

Hereinafter, the embodiments of the present invention will be described

in detail by way of working examples. The embodiments will be also described by way of comparative examples with respect to the working examples. It should be noted that the present invention is not limited to the following working examples.

5 (Working Example 1)

A magnetic-disk glass substrate of sample 1-1 was manufactured through (1) rough grinding processing, (2) shaping processing, (3) precision grinding processing, (4) edge surface polishing processing, (5) first main surface polishing processing, (6) chemical strengthening processing, (7) second main
10 surface polishing processing, and (8) cleaning processing.

[0072]

(1) Rough grinding processing

First, a disk-shaped glass substrate made of aluminosilicate glass that had a diameter of 66 mm ϕ and a thickness of 1.0 mm was obtained from molten
15 glass by direct pressing using upper, lower, and drum molds. It should be noted that other than using direct pressing, a glass substrate may be obtained by cutting a glass sheet manufactured with a downdraw method or a float method into a glass substrate having a predetermined size. As this aluminosilicate glass, glass for chemical strengthening containing SiO₂ in an amount of 58 to 75
20 wt%, Al₂O₃ in an amount of 5 to 23 wt%, Li₂O in an amount of 3 to 10 wt%, and Na₂O in an amount of 4 to 13 wt% was used.

[0073]

Next, rough grinding processing was performed on this glass substrate to improve the dimensional accuracy and shape accuracy. This rough grinding
25 processing was performed using a double-side grinding apparatus and loose abrasive particles. Specifically, a glass substrate 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 grinding apparatus were

rotated, and thus both surfaces of the glass substrate accommodated in the carrier were ground.

[0074]

(2) Shaping processing

5 Next, a cylindrical grindstone was used to create a hole in the center of the glass substrate, and the outer circumferential edge surface was ground so as to obtain a diameter of 65 mm ϕ . After that, predetermined chamfering processing was performed on the outer circumferential edge surface and the inner circumferential edge surface. It should be noted that a magnetic disk with
10 an outer diameter of 65 mm is generally used in a 2.5-inch HDD (hard disk drive).

[0075]

(3) Precision grinding processing

Using a double-side grinding apparatus, this precision grinding
15 processing was performed while the glass substrate held by a carrier was tightly placed between the upper and lower surface plates to which pellets obtained by fixing diamond abrasive particles with an acrylic resin were attached.

Specifically, the sun gear and the internal gear of the above-mentioned grinding apparatus were rotated, and thus both surfaces of the glass substrate
20 accommodated in the carrier were ground.

[0076]

(4) Edge surface polishing processing

Next, the edge surfaces (inner and outer circumferential edge surfaces) of the glass substrate were mirror-polished by brushing while the glass substrate
25 was rotated.

[0077]

(5) First main surface polishing processing

Next, first polishing processing to remove blemishes and distortion

remaining after the above-described grinding processing was performed using a double-side polishing apparatus. In the double-side polishing apparatus, a glass substrate held by a carrier is tightly placed between the upper and lower polishing surface plates to which polishing pads have been attached, the carrier
 5 is engaged with the sun gear and the internal gear, and the glass substrate is pressed between the upper and lower surface plates. Then, a polishing liquid is supplied between the polishing pads and the glass substrate surfaces to be polished, the upper and lower surface plates are rotated, and thus the glass substrate revolves while rotating on the surface plates using a planetary gear
 10 mechanism so that both surfaces of the glass substrate are polished simultaneously. Specifically, the first polishing processing was performed using a hard polisher (hard urethane foam) as a polisher. Water in which 10 wt% cerium oxide (average particle diameter (50% diameter) of 1 μm) was dispersed as an abrasive was used as the polishing liquid. The load applied to the glass
 15 substrate surface was set to 100 g/cm^2 , and the polishing time was set to 15 minutes.

[0078]

(6) Chemical strengthening processing

Next, chemical strengthening processing was performed on the glass
 20 substrate that had undergone the above-described cleaning. Chemical strengthening processing was performed by preparing a chemical strengthening liquid obtained by mixing and melting potassium nitrate and sodium nitrate, and immersing the glass substrate in the chemical strengthening liquid.

[0079]

25 (7) Second main surface polishing processing

Next, second polishing processing was performed using the same double-side polishing apparatus as used in the above-mentioned first polishing processing, but polishing pads of 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-finished surfaces with a surface roughness Ra of 0.2 nm or less, for example, while the flat surfaces obtained in the first polishing processing described above is maintained. As the polishing liquid, a polishing liquid prepared by dispersing 10 wt% colloidal silica (average particle diameter (50% diameter) 15 nm) as an abrasive in water and adjusted to be acidic (pH=2) by adding sulfuric acid was used. It should be noted that the load was set to 100 g/cm², and the polishing time was set to 10 minutes.

In order to check the surface roughness Ra after polishing, one substrate that was taken from the same lot was cleaned for 1200 seconds using only water and dried, and the measurement was performed under an AFM under the above-mentioned conditions. It was found that the Ra was 0.15 nm. However, a large number of colloidal silica particles attached to the substrate surface, and therefore, the substrate was not acceptable as a product.

[0080]

(8) Cleaning processing

Next, cleaning processing was performed on the glass substrate that had undergone the second polishing processing. Specifically, while ultrasonic waves were applied, the glass substrate was immersed for 600 seconds in a cleaning bath (liquid temperature: room temperature) accommodating a cleaning liquid prepared by adding above-mentioned tetramethylammonium hydroxide (TMAH) serving as an alkaline cleaning agent to pure water (TMAH concentration: about 0.3 mmol/L) such that the pH was 12.5. It should be noted that the cleaning liquid was reused.

At this time, TMAH containing neither Na ions nor K ions (not greater than the detection limit) was used. It should be noted that when this cleaning liquid was sampled to measure the concentration of Na ions and K ions using ion

chromatography, neither of these ions was detected.

After that, the glass substrate was immersed in another cleaning bath (pure water, room temperature), subjected to ultrasonic cleaning for 600 seconds, and then dried.

5 [0081]

With respect to one hundred glass substrates (sample 1-1) obtained through the above-described series of processing, the surface roughness (Ra) of the main surfaces of the glass substrates after being subjected to the above-mentioned cleaning processing was measured under an atomic force
10 microscope (AFM), and the amount of increase in the Ra (referred to as " ΔRa ") compared with Ra after the second polishing processing (before the cleaning processing) was determined. It was found that ΔRa was 0.04 nm. Table 1 shows the results. It should be noted that the above-mentioned value of surface roughness is an average value of the one hundred glass substrates that
15 were manufactured.

[0082]

(Sample 1-2)

The cleaning processing was performed in the same manner as in sample 1-1, except that a cleaning liquid in which NaOH was further included at
20 a concentration of 2 mmol/L and the amount of TMAH was adjusted such that the pH was 12.5 was used as the cleaning liquid of the above-mentioned cleaning processing.

(Sample 1-3)

The cleaning processing was performed in the same manner as in
25 sample 1-1, except that a cleaning liquid in which choline hydroxide containing neither Na ions nor K ions (at or below the detection limit) was used instead of TMAH and the amount of the choline hydroxide was adjusted such that the pH was 12.5 was used as the cleaning liquid of the above-mentioned cleaning

processing.

[0083]

(Sample 1-4)

The cleaning processing was performed in the same manner as in
5 sample 1-2, except that a cleaning liquid in which choline hydroxide containing
neither Na ions nor K ions (at or below the detection limit) was used instead of
TMAH to adjust the pH to 12.5 was used as the cleaning liquid of the
above-mentioned cleaning processing.

(Sample 1-5)

10 The cleaning processing was performed in the same manner as in
sample 1-1, except that a cleaning liquid in which
bis(2-hydroxyethyl)dimethylammonium hydroxide containing neither Na ions nor
K ions (at or below the detection limit) was used instead of TMAH to adjust the
pH to 12.5 was used as the cleaning liquid of the above-mentioned cleaning
15 processing.

[0084]

(Sample 1-6)

The cleaning processing was performed in the same manner as in
sample 1-1, except that a cleaning liquid in which
20 tris(2-hydroxyethyl)methylammonium hydroxide containing neither Na ions nor K
ions (at or below the detection limit) was used instead of TMAH to adjust the pH
to 12.5 was used as the cleaning liquid of the above-mentioned cleaning
processing.

(Sample 1-7)

25 The cleaning processing was performed in the same manner as in
sample 1-1, except that a cleaning liquid in which NaOH was used instead of
TMAH and the amount of NaOH was adjusted such that the pH was 12.5 was
used as the cleaning liquid of the above-mentioned cleaning processing. The

concentration of Na ions in this cleaning liquid was about 300 mmol/L.

[0085]

(Sample 1-8)

The cleaning processing was performed in the same manner as in
5 sample 1-1, except that a cleaning liquid in which KOH was used instead of
TMAH and the amount of KOH was adjusted such that the pH was 12.5 was
used as the cleaning liquid of the above-mentioned cleaning processing. The
concentration of K ions in this cleaning liquid was about 300 mmol/L.

[0086]

10 (Sample 1-9)

The cleaning processing was performed in the same manner as in
sample 1-1, except that a cleaning liquid in which
(3-hydroxypropyl)trimethylammonium hydroxide containing neither Na ions nor
K ions (at or below the detection limit) was used instead of TMAH to adjust the
15 pH to 12.5 was used as the cleaning liquid of the above-mentioned cleaning
processing.

(Sample 1-10)

The cleaning processing was performed in the same manner as in
sample 1-1, except that a cleaning liquid in which
20 (4-hydroxybutyl)trimethylammonium hydroxide containing neither Na ions nor K
ions (at or below the detection limit) was used instead of TMAH to adjust the pH
to 12.5 was used as the cleaning liquid of the above-mentioned cleaning
processing.

[0087]

25 (Sample 1-11)

The cleaning processing was performed in the same manner as in
sample 1-1, except that a cleaning liquid in which
(6-hydroxyhexyl)trimethylammonium hydroxide containing neither Na ions nor K

ions (at or below the detection limit) was used instead of TMAH to adjust the pH to 12.5 was used as the cleaning liquid of the above-mentioned cleaning processing.

(Sample 1-12)

5 The cleaning processing was performed in the same manner as in sample 1-1, except that a cleaning liquid in which (7-hydroxyheptyl)trimethylammonium hydroxide containing neither Na ions nor K ions (at or below the detection limit) was used instead of TMAH to adjust the pH to 12.5 was used as the cleaning liquid of the above-mentioned cleaning
10 processing.

[0088]

 With respect to the above-mentioned samples 1-2 to 1-12 as well, the amount of increase in the surface roughness (ΔRa) was measured, and the results were summarized in Table 1. "Total concentration of Na ions and K ions
15 in cleaning liquid" in Table 1 indicates a concentration just before the cleaning processing. In the samples other than samples 1-7 and 1-8, the concentration after the cleaning processing (performed on one hundred substrates in this embodiment) was measured, and it was confirmed that the measurement values were the same as those before the cleaning processing.

20 [0089]

[Table 1]

Table 1	Alkaline agent	Total concentration of Na ions and K ions in cleaning liquid (mmol/L)	ΔRa (nm)
Sample 1-1	TMAH	At or below detection limit	0.04
Sample 1-2	TMAH	2	0.05
Sample 1-3	Choline hydroxide	At or below detection limit	0.01
Sample 1-4	Choline hydroxide	2	0.02
Sample 1-5	Bis(2-hydroxyethyl)dimethylammonium hydroxide	At or below detection limit	0.01
Sample 1-6	Tris(2-hydroxyethyl)methylammonium hydroxide	At or below detection limit	0.01
Sample 1-7	NaOH	300	0.13
Sample 1-8	KOH	300	0.12
Sample 1-9	(3-hydroxypropyl)trimethylammonium hydroxide	At or below detection limit	0.01
Sample 1-10	(4-hydroxybutyl)trimethylammonium hydroxide	At or below detection limit	0.01
Sample 1-11	(6-hydroxyhexyl)trimethylammonium hydroxide	At or below detection limit	0.01
Sample 1-12	(7-hydroxyheptyl)trimethylammonium hydroxide	At or below detection limit	0.03

[0090]

As is clear from the results shown in Table 1, in order to reduce the surface roughness Ra of the main surface of the glass substrate subjected to the cleaning processing to a predetermined value or less, it is effective that the cleaning liquid contains TMAH and the organic alkali I of the present invention (samples 1-3 to 1-6 and 1-9 to 1-12), and that the content of sodium ions and potassium ions in the cleaning liquid is controlled.

10 [0091]

As is also clear from the comparison of samples 1-1 and 1-2 and

samples 1-3 and 1-4, it is preferable to use not TMAH but the organic alkali I of the present invention (e.g., choline hydroxide) as the alkaline agent because the amount of increase in the surface roughness can be further reduced. Since the organic alkali I of the present invention has a hydroxyl group as described above, the organic alkali I has a greater effect of adsorbing to silanol groups on the glass substrate surface to suppress the approach of Na ions and K ions to the silanol groups than TMAH, which has no hydroxyl groups, has, and as a result, the increase in roughness is highly effectively suppressed.

Moreover, it is found from the results from samples 1-5, 1-6, and 1-9 to 1-12 that the number of carbon atoms between a N atom and the hydroxyl group in the molecule of the organic alkali I is preferably 6 or less because ΔRa becomes the smallest.

When the cleaning liquid contained NaOH or KOH as the alkaline agent (samples 1-7 and 1-8), the roughness of the substrate increased dramatically after cleaning.

[0092]

Furthermore, glass substrates were continuously manufactured under the conditions of sample 1-3, and the number of batches that could be continuously processed in a case of reusing the same cleaning liquid was counted (Experiment 1). ΔRa of each batch was calculated, and it was judged that continuous processing was possible when a ΔRa of 0.05 nm or less was maintained.

The processing was performed in the same manner as in Experiment 1, except that a cleaning liquid was used in which only TMEDA was used as the organic alkali instead of choline hydroxide in sample 1-3 to adjust the pH to 12.5, and the number of batches that could be continuously processed was counted (Experiment 2).

The processing was performed in the same manner as in Experiment 1,

except that a cleaning liquid (the content of Na ions and K ions was at or below the detection limit) that contained choline hydroxide in an amount of 0.2 mmol as the organic alkali and to which TMEDA was added as appropriate to adjust the pH to 12.5 was used, and the number of batches that could be continuously
 5 processed was counted (Experiment 3).

Taking 1 as the count number in Experiment 1, the results obtained in Experiments 1 to 3 above were relatively compared. Table 2 shows the results. It is shown that the larger the value is, the longer a period of time for which the cleaning liquid can be used to continuously perform processing is, which is
 10 preferable for the reduction of manufacturing cost.

[0093]

[Table 2]

Table 2	Alkaline agent	Relative ratio of cleaning liquid usable time
Experiment 1	Choline hydroxide	1.0
Experiment 2	TMEDA	1.2
Experiment 3	Mixture of choline hydroxide and TMEDA	1.6

[0094]

15 First, Experiment 1 and Experiment 2 are compared. Although ΔRa of the first batch in Experiment 1 was slightly smaller and more favorable than that in Experiment 2, the period of time for which the cleaning liquid can be used to continuously perform processing in Experiment 2 improved compared with Experiment 1. It is inferred that this resulted from the chelating effect of
 20 TMEDA. On the other hand, the period of time for which the cleaning liquid can be used to continuously perform processing in Experiment 3 was 1.6 times longer than that in Experiment 1, namely it was significantly improved. It is inferred that this resulted from a synergistic effect of the adsorption effect of choline hydroxide with respect to the surfaces of the glass substrate and silica

abrasive particles and the chelating effect of TMEDA with respect to Na ions and K ions eluted from the glass substrate.

[0095]

(Working Example 2)

5 A magnetic-disk glass substrate of Working Example 2 (sample 2-1) was manufactured through (1) rough grinding processing, (2) shaping processing, (3) precision grinding processing, (4) edge surface polishing processing, (5) first main surface polishing processing, (6) chemical strengthening processing, (7) second main surface polishing processing, and (8) cleaning processing in the
10 same manner as in Working Example 1. It should be noted that the series of processing from (1) rough grinding processing to (7) second main surface polishing processing was performed in the same manner as in Working Example 1. Moreover, (8) cleaning processing was performed as follows.

[0096]

15 (8) Cleaning processing

Cleaning processing was performed on the glass substrate that had undergone the above-mentioned second polishing processing. Specifically, while ultrasonic waves were applied, the glass substrate was immersed for 600 seconds in a cleaning bath (liquid temperature: room temperature)
20 accommodating a cleaning liquid prepared by adding TMAH serving as an alkaline cleaning agent to pure water (TMAH concentration: about 0.3 mmol/L) such that the pH was 12.5. It should be noted that the cleaning liquid was reused.

At this time, TMAH containing neither Na ions nor K ions (not greater
25 than the detection limit) was used. It should be noted that when this cleaning liquid was sampled to measure the concentration of Na ions and K ions using ion chromatography, neither of these ions was detected.

After that, the glass substrate was immersed in another cleaning bath

(pure water, room temperature), subjected to ultrasonic cleaning for 600 seconds, and then dried.

[0097]

With respect to one hundred glass substrates (sample 2-1) obtained
5 through the above-described series of processing, the surface roughness (Ra) of
the main surfaces of the glass substrates after being subjected to the
above-mentioned cleaning processing was measured under an atomic force
microscope (AFM), and the amount of increase in the Ra (referred to as " ΔRa ")
compared with Ra after the second polishing processing (before the cleaning
10 processing) was determined. It was found that ΔRa was 0.04 nm. Table 3
shows the results. It should be noted that the above-mentioned value of
surface roughness is an average value of the one hundred glass substrates that
were manufactured.

Moreover, with respect to one hundred glass substrates (sample 2-1)
15 obtained, the number of pieces of foreign matter was evaluated. The
evaluation was performed by scanning the main surface of the obtained glass
substrate using a laser-type surface analysis apparatus and counting the
number of protrusion defects (protrusion defects caused by adhesion of foreign
matter) to evaluate the cleanliness after cleaning. As a result, the count
20 number was 100 or less (level 2 of the criterion described later), and the result
was favorable. It should be noted that the above-mentioned count number is
the average value obtained by dividing the total number counted on the surfaces
of one hundred glass substrates by the total number of surfaces of the one
hundred glass substrates. The results were evaluated based on the following
25 criteria.

<Criteria for number of pieces of foreign matter>

Level 1: 50 or less

Level 2: more than 50 and 100 or less

Level 3: more than 100 and 150 or less

Level 4: more than 150

(Levels 1 and 2 are acceptable.)

[0098]

5 (Sample 2-2)

The cleaning processing was performed in the same manner as in sample 2-1, except that a cleaning liquid in which KOH was further included at a concentration of 1 mmol/L and the amount of TMAH was adjusted such that the pH was 12.5 was used as the cleaning liquid of the above-mentioned cleaning processing.

(Sample 2-3)

The cleaning processing was performed in the same manner as in sample 2-1, except that a cleaning liquid in which NaOH was further included at a concentration of 2 mmol/L and the amount of TMAH was adjusted such that the pH was 12.5 was used as the cleaning liquid of the above-mentioned cleaning processing.

[0099]

(Sample 2-4)

The cleaning processing was performed in the same manner as in sample 2-1, except that a cleaning liquid in which KOH was further included at a concentration of 2 mmol/L and the amount of TMAH was adjusted such that the pH was 12.5 was used as the cleaning liquid of the above-mentioned cleaning processing.

(Sample 2-5)

The cleaning processing was performed in the same manner as in sample 2-1, except that a cleaning liquid in which NaOH was further included at a concentration of 4 mmol/L and the amount of TMAH was adjusted such that the pH was 12.5 was used as the cleaning liquid of the above-mentioned

cleaning processing.

[0100]

(Sample 2-6)

The cleaning processing was performed in the same manner as in
5 sample 2-1, except that a cleaning liquid in which NaOH and KOH each were
further included at a concentration of 2 mmol/L and the amount of TMAH was
adjusted such that the pH was 12.5 was used as the cleaning liquid of the
above-mentioned cleaning processing.

(Sample 2-7)

10 The cleaning processing was performed in the same manner as in
sample 2-1, except that a cleaning liquid in which TMEDA containing neither Na
ions nor K ions (at or below the detection limit) was used instead of TMAH and
the amount of the TMEDA was adjusted such that the pH was 12.5 was used as
the cleaning liquid of the above-mentioned cleaning processing.

15 [0101]

(Sample 2-8)

The cleaning processing was performed in the same manner as in
sample 2-4, except that a cleaning liquid in which TMEDA containing neither Na
ions nor K ions (at or below the detection limit) was used instead of TMAH to
20 adjust the pH to 12.5 was used as the cleaning liquid of the above-mentioned
cleaning processing.

(Sample 2-9)

The cleaning processing was performed in the same manner as in
sample 2-6, except that a cleaning liquid in which TMEDA containing neither Na
25 ions nor K ions (at or below the detection limit) was used instead of TMAH to
adjust the pH to 12.5 was used as the cleaning liquid of the above-mentioned
cleaning processing.

[0102]

(Sample 2-10)

The cleaning processing was performed in the same manner as in sample 2-1, except that a cleaning liquid in which TMAH containing Na ions and K ions as impurities at a total concentration of 6 mmol/L was used instead of TMAH and the amount of said TMAH was adjusted such that the pH was 12.5 was used as the cleaning liquid of the above-mentioned cleaning processing. It is inferred that the impurities were generated during the manufacturing process of TMAH.

[0103]

10 (Sample 2-11)

The cleaning processing was performed in the same manner as in sample 2-1, except that a cleaning liquid in which NaOH was used instead of TMAH and the amount of NaOH was adjusted such that the pH was 12.5 was used as the cleaning liquid of the above-mentioned cleaning processing. The concentration of Na ions in this cleaning liquid was about 300 mmol/L.

(Sample 2-12)

The cleaning processing was performed in the same manner as in sample 2-1, except that a cleaning liquid in which KOH was used instead of TMAH and the amount of KOH was adjusted such that the pH was 12.5 was used as the cleaning liquid of the above-mentioned cleaning processing. The concentration of K ions in this cleaning liquid was about 300 mmol/L.

[0104]

(Sample 2-13)

The cleaning processing was performed in the same manner as in sample 2-1, except that a cleaning liquid in which N,N,N',N'',N"-pentamethyldiethylenetriamine containing neither Na ions nor K ions (at or below the detection limit) was used instead of TMAH to adjust the pH to 12.5 was used as the cleaning liquid of the above-mentioned cleaning

processing.

(Sample 2-14)

The cleaning processing was performed in the same manner as in sample 2-1, except that a cleaning liquid in which

5 tris[2-(dimethylamino)ethyl]amine containing neither Na ions nor K ions (at or below the detection limit) was used instead of TMAH to adjust the pH to 12.5 was used as the cleaning liquid of the above-mentioned cleaning processing.
[0105]

(Sample 2-15)

10 The cleaning processing was performed in the same manner as in sample 2-7, except that a cleaning liquid in which tetramethylammonium dodecylbenzene sulfonate (quaternary ammonium cation salt) serving as an anionic surfactant was further included at a concentration of 100 mmol/L and the amount of TMEDA was adjusted such that the pH was 12.5 was used as the
15 cleaning liquid of the above-mentioned cleaning processing. It should be noted that neither Na ions nor K ions were detected in this cleaning liquid.

(Sample 2-16)

The cleaning processing was performed in the same manner as in sample 2-7, except that a cleaning liquid in which sodium dodecylbenzene
20 sulfonate (sodium salt) serving as an anionic surfactant was further included at a concentration of 100 mmol/L and the amount of TMEDA was adjusted such that the pH was 12.5 was used as the cleaning liquid of the above-mentioned cleaning processing. The concentration of Na ions in this cleaning liquid was about 100 mmol/L.

25 [0106]

With respect to the above-mentioned samples 2-2 to 2-16 as well, the amount of increase in the surface roughness (ΔRa) was measured, and the number of pieces of foreign matter was counted. The results are summarized

in Table 3 and Table 4. "Total concentration of Na ions and K ions in cleaning liquid" in Table 3 indicates a concentration just before the cleaning processing. In the samples other than samples 2-10 to 2-12, the concentration after the cleaning processing (performed on one hundred substrates in this embodiment) was measured, and it was confirmed that the measurement values were the same as those before the cleaning processing. Moreover, with respect to the evaluation results of the number of pieces of foreign matter of the samples, which are not shown in Table 3, samples 2-11 and 2-12 were evaluated as level 1 and the other samples were evaluated as level 2. Therefore, all the samples were acceptable.

[0107]

[Table 3]

Table 3	Alkaline agent	Total concentration of Na ions and K ions in cleaning liquid (unit: mmol/L)	ΔRa (nm)
Sample 2-1	TMAH	0	0.04
Sample 2-2	TMAH	1 (K ions)	0.04
Sample 2-3	TMAH	2 (Na ions)	0.05
Sample 2-4	TMAH	2 (K ions)	0.05
Sample 2-5	TMAH	4 (Na ions)	0.05
Sample 2-6	TMAH	4 (Na ions and K ions)	0.05
Sample 2-7	TMEDA	0	0.03
Sample 2-8	TMEDA	2 (K ions)	0.03
Sample 2-9	TMEDA	4 (Na ions and K ions)	0.04
Sample 2-10	TMAH	6 (Na ions and K ions)	0.11
Sample 2-11	NaOH	About 300 (Na ions)	0.13
Sample 2-12	KOH	About 300 (K ions)	0.13
Sample 2-13	N,N,N',N'',N''-pentamethyldiethylenetriamine	0	0.03
Sample 2-14	Tris[2-(dimethylamino)ethyl]amine	0	0.03

[0108]

As is clear from the results shown in Table 3, in order to reduce the surface roughness Ra of the main surface of the glass substrate subjected to the

cleaning processing to a predetermined value or less, it is necessary to control the content of sodium ions and potassium ions in the cleaning liquid. In particular, in order to cause the amount of increase in the surface roughness (ΔRa) to be 0.05 nm or less, it is preferable to perform the cleaning processing while the total amount (total content) of sodium ions and potassium ions in the cleaning liquid is suppressed to 4 mmol/L or less.

Even when TMAH is used as the alkaline agent, the case where TMAH contains Na ions and K ions in a large amount as impurities and the content of sodium ions and potassium ions in the cleaning liquid is greater than 4 mmol/L as in sample 2-10 is not preferable because ΔRa increases. It should be noted that although TMAH was used as the alkaline agent in sample 2-10, the same applies to a case where the organic alkali I of the present invention is used. That is, the case where the content of sodium ions and potassium ions in the cleaning liquid is greater than 4 mmol/L is not preferable because ΔRa increases.

[0109]

As is also clear from the comparison of samples 2-4 and 2-6 and samples 2-8 and 2-9, it is preferable to use not TMAH but TMEDA as the alkaline agent because the amount of increase in the surface roughness can be further reduced. TMEDA is considered to have two effects: one is the effect of adsorbing to silanol groups on the glass substrate surface to suppress the approach of Na ions and K ions to the silanol groups; and the other is the chelating effect with respect to Na ions and K ions, as described above, and therefore, it is conceivable that TMEDA exhibits a higher effect of suppressing an increase in roughness than TMAH, which has no chelating effect.

[0110]

Other advantages of TMEDA were confirmed. Under the conditions of samples 2-1, 2-7, 2-13, and 2-14, a continuous cleaning test was performed on

100 batches (25 glass substrates per batch) without replacing the cleaning liquid, and ΔRa of the glass substrate of the 100th batch was compared. As a result, in sample 2-1 (TMAH), ΔRa was larger by 0.01 nm than that of the first batch, and in samples 2-7, 2-13, and 2-14, ΔRa was the same as that of the first batch.

- 5 It is conceivable that under the conditions of samples 2-7, 2-13, and 2-14, the increase in roughness was suppressed by TMEDA or a derivative of TMEDA coordinating with Na ions eluted from the glass to form chelates.

[0111]

[Table 4]

Table 4	Alkaline agent and additive	Total concentration of Na ions and K ions in cleaning liquid (unit: mmol/L)	ΔRa (nm)	Evaluation of number of pieces of foreign matter
Sample 2-7	TMEDA	0	0.03	Level 2
Sample 2-15	TMEDA, anionic surfactant (counter-ion: TMA ion)	0	0.03	Level 1
Sample 2-16	TMEDA, anionic surfactant (counter-ion: Na ion)	About 100	0.13	Level 1

10

[0112]

- As is clear from the results shown in Table 4, it is possible to further improve the cleanliness of the glass substrate surface by performing the cleaning processing in a state in which an anionic surfactant is added in addition to an alkaline agent. However, if the surfactant contains Na ions, the content of Na ions in the cleaning liquid becomes extremely large, and as a result, the surface roughness increases. Na ions are often used as counter-ions in anionic additives such as an anionic surfactant, but it was found that when cleaning is performed using the etching effect under alkaline conditions as in the present invention, Na ions cause the increase in the surface roughness.
- 15
- 20

[0113]

(Manufacturing of magnetic disk)

Magnetic disks for perpendicular magnetic recording were manufactured by performing the following film forming steps on the magnetic-disk glass

5 substrates of sample 1-3 and sample 2-7 obtained as described above.

Specifically, an adherent 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, a base layer 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 protecting

10 layer, and a lubricant layer were formed in sequence on the glass substrate.

The protecting layer is for preventing degradation of the magnetic recording layer caused by contact with a magnetic head. The protecting layer is made of hydrogenated carbon and yields wear resistance. The lubricant layer was formed by a dipping method using an alcohol-modified perfluoropolyether liquid

15 lubricant.

The obtained magnetic disks were incorporated into HDDs 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 environment at a temperature of 80°C and a humidity of 80%RH. As a

20 result, there was no particular trouble, and good results were obtained.

Description of Reference Numerals

[0114]

- | | | |
|----|--------|---------------------------|
| | 1 | Glass substrate |
| 25 | 11 | Main surface of substrate |
| | 12, 13 | Edge surface of substrate |

CLAIMS

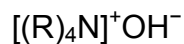
1. A method for manufacturing a magnetic-disk glass substrate comprising performing cleaning processing in which a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline cleaning liquid and cleaned,
5 wherein a glass composition of the glass substrate includes at least one of sodium and potassium,
the cleaning liquid used in the cleaning processing contains an organic alkali represented by General Formula I:
10
$$[(R)_4N]^+OH^-$$
where R represents an alkyl group, and at least one of four alkyl groups binding to a N atom has at least one hydroxyl group (OH group), and
the cleaning processing is performed while a content of sodium ions and potassium ions in the cleaning liquid is suppressed.
15
2. The method for manufacturing a magnetic-disk glass substrate according to claim 1, wherein at least one of four Rs binding to the N atom in the organic alkali is a linear alkyl group having a hydroxyl group at a terminus that does not bind to the N atom.
- 20 3. The method for manufacturing a magnetic-disk glass substrate according to claim 2, wherein the linear alkyl group having a hydroxyl group at a terminus that does not bind to the N atom in the organic alkali has two or more carbon atoms between the N atom and the hydroxyl group.
4. The method for manufacturing a magnetic-disk glass substrate according to any of claims 1 to 3, wherein the cleaning processing is performed while a total amount of sodium ions and potassium ions in the cleaning liquid is suppressed to 4 millimole/L or less.
- 25

5. A method for manufacturing a magnetic-disk glass substrate

comprising performing cleaning processing in which a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline cleaning liquid and cleaned,

wherein a glass composition of the glass substrate includes at least one
5 of sodium and potassium,

the cleaning liquid used in the cleaning processing contains an organic alkali represented by General Formula I:



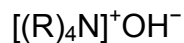
where R represents an alkyl group, and at least one of four alkyl groups binding
10 to a N atom has at least one hydroxyl group (OH group), and

the cleaning processing is performed under a condition that a total amount of sodium ions and potassium ions in the cleaning liquid is 4 millimole/L or less.

6. A method for manufacturing a magnetic-disk glass substrate
15 comprising performing cleaning processing in which a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline cleaning liquid and cleaned,

wherein a glass composition of the glass substrate includes at least one of sodium and potassium,

20 the cleaning liquid used in the cleaning processing contains an organic alkali represented by General Formula I:



where R represents an alkyl group, and at least one of four alkyl groups binding
to a N atom has at least one hydroxyl group (OH group), and

25 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 surface roughness (Ra) before the cleaning processing and a total amount of sodium ions and potassium ions in the cleaning

liquid is obtained in advance, the total amount 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 0.05 nm or less, and the cleaning processing is performed while a condition that the total amount of sodium ions and potassium ions in the cleaning liquid is less than or equal to the determined total amount is maintained.

7. The method for manufacturing a magnetic-disk glass substrate according to any of claims 1 to 6, wherein the cleaning liquid further contains at least one selected from N,N'-tetramethylethylenediamine and derivatives of N,N'-tetramethylethylenediamine.

8. A method for manufacturing a magnetic-disk glass substrate comprising performing cleaning processing in which a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline cleaning liquid and cleaned, wherein a glass composition of the glass substrate includes at least one of sodium and potassium,

the cleaning liquid used in the cleaning processing contains at least one alkaline agent selected from tetramethylammonium hydroxide, N,N'-tetramethylethylenediamine, and derivatives of N,N'-tetramethylethylenediamine, and

in order to reduce roughening of the glass substrate surface caused by the cleaning processing, the cleaning processing is performed while a content of sodium ions and potassium ions in the cleaning liquid used in the cleaning processing is suppressed.

9. The method for manufacturing a magnetic-disk glass substrate according to claim 8, wherein the cleaning processing is performed while a total amount of sodium ions and potassium ions in the cleaning liquid is suppressed to 4 millimole/L or less.

10. A method for manufacturing a magnetic-disk glass substrate comprising performing cleaning processing in which a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline cleaning liquid and cleaned,

5 wherein a glass composition of the glass substrate includes at least one of sodium and potassium,

the cleaning liquid used in the cleaning processing contains at least one alkaline agent selected from tetramethylammonium hydroxide,

N,N'-tetramethylethylenediamine, and derivatives of

10 N,N'-tetramethylethylenediamine, and

the cleaning processing is performed under a condition that a total amount of sodium ions and potassium ions in the cleaning liquid is 4 millimole/L or less.

11. A method for manufacturing a magnetic-disk glass substrate
15 comprising performing cleaning processing in which a glass substrate surface polished to a mirror-finished surface is brought into contact with an alkaline cleaning liquid and cleaned,

wherein a glass composition of the glass substrate includes at least one of sodium and potassium,

20 the cleaning liquid used in the cleaning processing contains at least one alkaline agent selected from tetramethylammonium hydroxide,

N,N'-tetramethylethylenediamine, and derivatives of

N,N'-tetramethylethylenediamine, and

a relationship between an amount of increase in surface roughness (Ra)
25 of a main surface of the glass substrate after being subjected to the cleaning processing with respect to surface roughness (Ra) before the cleaning processing and a total amount of sodium ions and potassium ions in the cleaning liquid is obtained in advance, the total amount 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 0.05 nm or less, and the cleaning processing is performed while a condition that the total amount of sodium ions and potassium ions in the cleaning liquid is less than or equal to
5 the determined total amount is maintained.

12. The method for manufacturing a magnetic-disk glass substrate according to any of claims 1 to 5 and 7 to 10, wherein a difference between surface roughness (Ra) of a main surface of the glass substrate after being subjected to the cleaning processing and surface roughness (Ra) of a main
10 surface of the glass substrate just before the cleaning processing is 0.05 nm or less.

13. The method for manufacturing a magnetic-disk glass substrate according to any of claims 1 to 12, wherein the cleaning processing is performed after polishing processing in which a main surface of the glass substrate is
15 polished using a polishing liquid that contains colloidal silica abrasive particles and is adjusted so as to be in an acidic range.

14. A method for manufacturing a magnetic disk comprising forming at least a magnetic recording layer on the magnetic-disk glass substrate manufactured with the method for manufacturing a magnetic-disk glass
20 substrate according to any of claims 1 to 13.