

DESCRIPTION

Title of the Invention

METHOD FOR MANUFACTURING MAGNETIC-DISK GLASS SUBSTRATE
5 AND METHOD FOR MANUFACTURING MAGNETIC DISK

Technical Field

[0001]

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

Background Art

15 [0002]

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

[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 obtain a highly smooth magnetic disk

5 surface, a highly smooth substrate surface is ultimately required, and thus it is necessary to precisely polish the surface of the glass substrate. However, only performing highly precise polishing is not sufficient, and thus in order to obtain a clean substrate surface, foreign matter adhering to the substrate surface needs to be removed by cleaning after the polishing.

10 As the conventional method, Patent Document 1 discloses a method of cleaning the substrate through alkaline (pH 8 to 13) cleaning after the substrate is polished with a polishing liquid containing a polyvalent amine, for example. Also, Patent Document 2 discloses a method of cleaning the substrate with an alkaline cleaning agent having a pH of 10 or more and containing alkali agent
15 and aldonic acids after polishing.

Prior Art Document

Patent Document

[0004]

20 Patent Document 1: JP-A-2012-107226

Patent Document 2: JP-A-2010-86563

Summary of the Invention

Problem to be Solved by the Invention

25 [0005]

With currently available HDDs, it is possible to realize a recording density of about 500 gigabits per square inch and store about 320 gigabytes of information per 2.5-inch (diameter of 65 mm) magnetic disk, for example, and

there is demand for the realization of a further increase in recording density, such as 375 to 500 gigabytes, or even 1 terabyte, for example. Following such demand for HDDs with a larger storage capacity in recent years, the need for improvement in the surface quality of a substrate is greater than ever.

5 Next-generation substrates for magnetic disks of 375 to 500 gigabytes, for example, such as those described above will greatly influence the characteristics of the medium, and thus a further improvement from currently available HDDs is required, not only in terms of the surface roughness of the substrate, but also with regard to eliminating surface defects resulting from the adherence of foreign
10 matter or the like.

[0006]

Next-generation substrates will greatly influence the characteristics of the medium for reasons such as the following.

A significant reduction in the flying height (the gap between the magnetic
15 head and the surface of medium (magnetic disk)) of a magnetic head (lower flying height) is achieved. This reduces the distance between the magnetic head and the magnetic layer of the medium, which makes it possible to also pick up signals of smaller magnetic particles, and thereby a high recording density is achieved. In recent years, in order to realize a lower flying height than
20 previously available, magnetic heads have been provided with a function called DFH (Dynamic Flying Height). This function causes only the recording and reproduction element portion of the magnetic head to protrude toward the medium surface by providing a heating unit such as a very small heater in the vicinity of the recording and reproduction element portion of the magnetic head.
25 In the future, it is expected that the DFH function will greatly reduce the gap between the element portion of the magnetic head and the medium surface to less than 2 nm or less than 1 nm. Under such circumstances, even if the average roughness of the substrate surface is reduced to an extremely low level,

if adherence of extremely small foreign matter (for example, small foreign matter having a length of about 10 to 40 nm in an in-plane direction of the main surface), which was conventionally not a problem, causes surface defects that protrude slightly, these defects also serve as protruding defects on the medium surface, and therefore there is a greater risk that the magnetic head will collide with the foreign matter defects.

[0007]

Incidentally, according to studies conducted by the inventors, it has been found that even with various types of conventional precision polishing technology and precision cleaning technology such as the methods disclosed in the Patent Documents, or a simple combination thereof, it is not possible to achieve both low roughness and high degree of cleanliness after cleaning.

The need for improvement in the surface quality of a substrate following demand for HDDs with a larger storage capacity in recent years is greater than ever, and there is a limit to the realization of further improvement in the surface quality of a substrate with the conventional improvement method. It should be noted that the alkali agent here refers to a substance that is alkaline when dissolved in water.

[0008]

The present invention has been made in order to resolve such issues in the conventional technology, and an object thereof is first to provide a method for manufacturing a magnetic-disk glass substrate that enables cleaning processing causing as little deterioration as possible to the roughness of a smooth surface obtained through precision polishing, and accordingly achieves a low roughness (high smoothness), and second to provide a method for manufacturing a magnetic-disk glass substrate that enables highly clean cleaning.

Means to Solve the Problem

[0009]

In order to increase the cleanliness of a substrate, foreign matter adhering to the substrate surface needs to be removed by cleaning, and in order to achieve that, cleaning with an alkaline chemical liquid having a high pH (strong alkalinity) is preferable to achieve a high cleanliness. The reason for this is because the surface of glass is etched with an alkaline chemical liquid having a high alkalinity, and therefore even the foreign matter attached thereto can be removed thoroughly. However, with the conventional alkaline cleaning, the etching effect on glass increases as the alkalinity increases, and therefore the roughness of a substrate surface increases due to the alkaline cleaning, and roughness of the very smooth surface that is obtained through precision polishing cannot be maintained. In view of this, the inventors searched for a method for suppressing an increase in the surface roughness of a substrate while a cleaning power of alkaline cleaning is maintained. As a result, the inventors found that the use of a specific alkali agent could specifically suppress an increase in roughness.

Also, the inventors found that an increase amount of roughness is also affected by not only the alkalinity of an alkali agent used in cleaning but also the type of cation that is paired with a OH ion. Furthermore, the inventors found that the reason why the degree of surface roughening differs in accordance with the type of organic alkali agent or a batch is that the amounts of sodium ions and potassium ions that are present in the cleaning liquid differ from each other. Here, an organic alkali such as tetramethylammonium hydroxide (TMAH) does not originally include sodium or potassium ions, but it is conceivable that sodium, potassium, or the like will be inevitably mixed in, in an industrial manufacturing process, and it was found that this relates to the surface roughening of the glass substrate.

[0010]

The inventors accomplished the invention as a result of further intensive studies based on the obtained findings.

That is, the present invention has the following aspects.

5 (Aspect 1)

A method for manufacturing a magnetic-disk glass substrate, including processing for cleaning a glass substrate, in which the cleaning processing includes processing for bringing the glass substrate into contact with a cleaning liquid containing at least one of guanidine and imidazole, a relationship between
10 an increase amount of a surface roughness (Ra) of a main surface of the glass substrate after the cleaning processing with respect to the surface roughness (Ra) of the main surface of the glass substrate before the cleaning processing and a total concentration of sodium ions and potassium ions in a cleaning liquid that is used in the cleaning processing is obtained in advance, a total
15 concentration of sodium ions and potassium ions in the cleaning liquid with which an increase amount of the surface roughness (Ra) reaches 0.06 nm or less is determined based on the obtained relationship, and the cleaning processing is performed on the glass substrate having a main surface that is mirror-polished, under a condition that a total concentration of sodium ions and
20 potassium ions in the cleaning liquid is the determined concentration or less.

[0011]

(Aspect 2)

A method for manufacturing a magnetic-disk glass substrate, including processing for cleaning a glass substrate, in which the glass substrate contains
25 at least one component of sodium and potassium in glass components, a cleaning liquid containing at least one of guanidine and imidazole is used, and the cleaning processing is performed on the glass substrate having a main surface that is mirror-polished, while at least a portion of the cleaning liquid is

replaced such that a total amount of sodium ions and potassium ions in the cleaning liquid does not reach 200 ppm or more.

[0012]

(Aspect 3)

5 A method for manufacturing a magnetic-disk glass substrate, including processing for cleaning a glass substrate, in which the cleaning processing includes processing for bringing the glass substrate into contact with a cleaning liquid containing at least one of guanidine and imidazole, and the cleaning processing is performed with a total amount of sodium ions and potassium ions
10 in the cleaning liquid being suppressed to less than 200 ppm.

[0013]

(Aspect 4)

 The method for manufacturing a magnetic-disk glass substrate according to any of Aspects 1 to 3, in which the glass substrate contains at least
15 one component of sodium and potassium in glass components.

(Aspect 5)

 The method for manufacturing a magnetic-disk glass substrate according to any of Aspects 1 to 4, in which the cleaning liquid further contains at least one of a surfactant, a chelating agent, and a dispersant, and the cleaning
20 processing is performed with a total amount of sodium ions and potassium ions in the cleaning liquid being suppressed to less than 200 ppm.

[0014]

(Aspect 6)

 The method for manufacturing a magnetic-disk glass substrate
25 according to any of Aspects 2 to 5, in which a difference between a 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 immediately before the cleaning processing is 0.06 nm or less.

(Aspect 7)

The method for manufacturing a magnetic-disk glass substrate according to any of Aspects 1 to 6, in which the surface roughness (Ra) of the main surface of the glass substrate immediately before the cleaning processing

5 is 0.13 nm or less.

[0015]

(Aspect 8)

The method for manufacturing a magnetic-disk glass substrate according to any of Aspects 1 to 7, in which a pH of the cleaning liquid is 10 or

10 more.

(Aspect 9)

The method for manufacturing a magnetic-disk glass substrate according to any of Aspects 1 to 8, in which the cleaning processing is cleaning processing that is performed after a final polishing step among polishing steps of

15 polishing the main surface of the glass substrate with polishing abrasive particles.

(Aspect 10)

The method for manufacturing a magnetic-disk glass substrate according to Aspect 9, in which a polishing liquid that is used in the final

20 polishing is alkaline.

(Aspect 11)

A method for manufacturing a magnetic disk, in which at least a magnetic recording layer is formed on a magnetic-disk glass substrate that is manufactured with the method for manufacturing a magnetic-disk glass

25 substrate according to any of Aspects 1 to 10.

Effect of the Invention

[0016]

According to the present invention, cleaning processing can be performed causing as little deterioration as possible to the roughness of a smooth surface obtained in precision polishing, and accordingly a method for manufacturing a magnetic-disk glass substrate that can achieve a low roughness (high smoothness) can be provided. Also, according to the present invention, a method for manufacturing a magnetic-disk glass substrate that can perform highly clean cleaning can be provided. According to the present invention, a high-quality magnetic-disk glass substrate in which the roughness of the substrate main surface can be reduced more and surface defects resulting from foreign matter adherence can be further reduced compared to the conventional products can be manufactured at low cost. The magnetic-disk glass substrate obtained by the present invention can be preferably used as, in particular, a next-generation substrate with stricter requirements on substrate surface quality than currently available substrates. Also, even in the case where the glass substrate obtained by the present invention is used in combination with a magnetic head that is provided with the DFH function and is designed to have a very low flying height, a highly reliable magnetic disk that is capable of performing stable operations for a long period of time can be obtained.

20

Brief Description of the Drawings

[0017]

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

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

25 FIG. 3 is a longitudinal cross-sectional view of a schematic configuration of a double-side polishing device.

Mode for Embodying the Invention

[0018]

Hereinafter, an embodiment according to the present invention will be described in detail.

5 The magnetic-disk glass substrate is generally manufactured through a rough grinding step (rough lapping step), a shape processing step, a precision grinding step (precision lapping step), an edge surface polishing step, a main surface polishing step (first polishing step and second polishing step), a chemical strengthening step, and the like.

10 This magnetic-disk glass substrate is manufactured by first molding a disk-shaped glass substrate (glass disk) from molten glass by direct pressing. It should be noted that a glass substrate may be obtained by cutting plate glass manufactured with a downdraw method or a float method other than using direct pressing into a predetermined size. Next, grinding (lapping) for enhancing the dimensional accuracy and shape accuracy is performed on this molded glass
15 substrate. In this grinding step, a double-side lapping device is generally used to grind the main surfaces of the glass substrate with hard abrasive particles such as diamond particles. By grinding the main surfaces of the glass substrate in this manner, the glass substrate is processed so as to have a predetermined substrate thickness and flatness and to obtain a predetermined
20 surface roughness.

[0019]

After this grinding step ends, the polishing processing for obtaining a high precision flat surface (mirror surface) is then performed. It is preferable to perform a method for polishing a glass substrate using a polishing pad made of
25 polyurethane or the like while supplying a slurry (polishing liquid) containing an abrasive that is made of a metal oxide such as cerium oxide or colloidal silica.

[0020]

A polishing liquid according to the present embodiment may contain an abrasive and water, which is a solvent, in combination, and also a pH adjusting agent for adjusting the pH of the polishing liquid, and other additive agents as required.

5 [0021]

Also, a polishing liquid that is adjusted to be acidic is preferably used as the above-described polishing liquid that is applied to a polishing step (in particular, a final polishing step (a second polishing step, which will be described later)). For example, a polishing liquid is adjusted by adding sulfuric acid to a
10 polishing liquid to reach a pH of 2 to 4. The polishing liquid that is adjusted to be acidic is preferably used in the interest of the productivity and cleanliness.

Also, it is more preferable that cleaning processing of the present invention is applied to cleaning processing performed after the polishing step of polishing a main surface of a glass substrate with the polishing liquid that
15 contains colloidal silica polishing abrasive particles and is adjusted to be alkaline. In the case where polishing is performed on a glass substrate in an acidic condition, a portion of elements comes out from the surface of the glass substrate due to the leaching action of acid, whereafter etching is likely to be performed locally and irregularly when alkaline cleaning is performed, resulting
20 in an increase in roughening of the glass substrate surface after cleaning. Such a phenomenon is relatively unlikely to occur in the case where polishing is performed under the condition that the polishing liquid is adjusted to be alkaline. Therefore, in the case where cleaning processing is performed on the glass substrate with a strong alkaline cleaning liquid after the polishing step, it is
25 preferable to perform polishing under the alkaline condition because the surface roughness can be reduced relatively compared to the case in which polishing is performed under an acidic condition. From the point of view of reducing a difference in pH between the polishing liquid and the cleaning liquid, the pH of

the polishing liquid when polishing is performed under the alkaline condition is preferably 10 or more, and more preferably 11 or more. Also, from the point of view of ease of handling, the pH of the polishing liquid is preferably 13 or less.
[0022]

5 From the point of view of polishing efficiency, it is preferable to use the polishing abrasive particles of colloidal silica or the like that are included in the polishing liquid and that have an average particle diameter of about 10 to 100 nm. In particular, from the point of view of achieving a further reduction in surface roughness, in the present invention, it is preferable to use the polishing
10 abrasive particles that are included in the polishing liquid used in the final polishing step (a later-described second polishing step performed downstream) and have an average particle diameter of about 10 to 40 nm, and it is particularly preferable to use minute polishing abrasive particles that have an average
15 particle diameter of about 10 to 20 nm. However, the more minute polishing abrasive particles are, the more difficult it is to remove the polishing abrasive particles once the polishing abrasive particles are adsorbed by the glass substrate. The cleaning processing of the present invention is particularly effective because if the cleaning processing is applied after polishing is
20 performed with very minute colloidal silica polishing abrasive particles that have an average particle diameter of 20 nm or less, the glass substrate surface can be cleaned by cleaning off the polishing abrasive particles and extremely low surface roughness can be maintained.

[0023]

25 It should be noted that in the present invention, the above-described average particle diameter denotes a particle diameter at which a cumulative curve reaches 50% when the cumulative curve is derived by setting the total 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 device.

5 [0024]

Also, colloidal silica abrasive particles produced by hydrolyzing an organic silicon compound can be used as the colloidal silica abrasive particles that are used in the present invention. Although such abrasive particles are unlikely to aggregate, the abrasive particles are likely to adhere strongly to the
10 glass substrate surface that has undergone the polishing step, and thus it is effective to apply the cleaning processing of the present invention.

[0025]

In the present invention, there is no particular limitation on a polishing method in the polishing step, but it is sufficient that the surface of the glass
15 substrate is polished to be a mirror surface by bringing the glass substrate and the polishing pad into contact with each other, and moving the polishing pad and the glass substrate relative to each other while supplying the polishing liquid containing polishing abrasive particles, for example.

For example, FIG. 3 is a longitudinal cross-sectional view showing a
20 schematic configuration of a planetary double-side polishing device that can be used in the step of polishing a glass substrate. The double-side polishing device shown in FIG. 3 includes a sun gear 2, an internal gear 3 arranged concentrically on the outside of the sun gear 2, a carrier 4 that is engaged with the sun gear 2 and the internal gear 3 and revolves and rotates in response to
25 the rotation of the sun gear 2 or the internal gear 3, an upper surface plate 5 and a lower surface plate 6 to which polishing pads 7 that are capable of holding a product 1 to be polished that is held by the carrier 4 are respectively attached,

and a polishing liquid supplying portion (not shown) that supplies the polishing liquid between the upper surface plate 5 and the lower surface plate 6.

[0026]

At the time of polishing processing, by using such a double-side
5 polishing device, the product 1 to be polished, that is, the glass substrate, held by the carrier 4 is held between the upper surface plate 5 and the lower surface plate 6, and then both of the upper and lower surfaces of the product 1 to be polished are polished while the polishing liquid is supplied between each of the polishing pads 7 of the upper and lower surface plates 5 and 6 and the product 1
10 to be polished and the carrier 4 revolves and rotates in response to the rotation of the sun gear 2 and the internal gear 3.

[0027]

It is particularly preferable that a soft polisher polishing pad (suede pad) is used as the polishing pad used for the final polishing. It is preferable that the
15 hardness of the polishing pad is set to an Asker C hardness of 60 or more to 80 or less. It is preferable that the surface of the polishing pad that abuts against the glass substrate is made of resin foam in which foam pores are formed, particularly polyurethane foam. When polished in this manner, the glass substrate surface can be polished so as to be a smooth mirror surface.

20 [0028]

According to an embodiment of the present invention, in cleaning processing for cleaning a glass substrate with a cleaning liquid containing a cleaning agent, the cleaning processing being performed after the step of polishing the glass substrate main surface, the cleaning processing includes
25 processing for bringing the glass substrate into contact with the cleaning liquid containing a specific alkali agent having the capability of etching a glass substrate, specifically, containing at least one of guanidine and imidazole.

[0029]

As a result of searching for a method for suppressing an increase in the surface roughness of a substrate, the inventors found that an increase in roughness can be suppressed specifically by using a specific alkali agent, that is, guanidine, while maintaining the cleaning power of alkaline cleaning.

5 Regardless of the fact that the abovementioned guanidine has a high alkalinity (equivalent to KOH, for example) and a great foreign matter removal effect resulting from the etching action on glass, there is little increase in the roughness of the substrate surface after cleaning. Therefore, by cleaning the glass substrate using the cleaning liquid containing guanidine as the alkaline
10 cleaning agent, it is possible to realize a low roughness (high smoothness) of the glass substrate after cleaning, obtain good cleaning properties, and achieve high cleanliness.

[0030]

 Although there is no particular limitation on the content of guanidine in
15 the cleaning liquid, it is preferable to set the content of guanidine to be in a range of 0.005 mol/L to 1 mol/L, for example. If the content of guanidine is less than 0.005 mol/L, an etching rate decreases, and therefore there is a risk that it will take time to obtain the foreign matter removal effect resulting from the etching action on glass, and the productivity deteriorates. On the other hand, if the
20 content of guanidine is greater than 1 mol/L, there are cases in which sufficient alkaline cleaning action is obtained, but an etching rate increases due to alkaline, and therefore if a glass composition includes sodium or potassium, the elution amount thereof increases, as a result of which the need to frequently perform a process for adjusting sodium ions and potassium ions arises. Also, there are
25 cases in which variation occurs in the inner diameter or the outer diameter of the substrate, which needs very strict management, and the inner diameter or the outer diameter is out of a predetermined range. Also, the alkalinity increases excessively, and therefore the cleaning liquid needs to be handled with caution.

Also, in the case where the cleaning liquid is used cyclically, if Na ions and K ions in the cleaning liquid increase due to the elution from the glass substrate, addition of a chelating agent or the like that captures alkali metal ions is effective.

5 [0031]

Also, as a result of searching for the method for suppressing an increase in the surface roughness of a substrate while maintaining the cleaning power of alkaline cleaning, the inventors found that an increase in roughness can be specifically suppressed by using imidazole.

10 Regardless of the fact that the abovementioned imidazole also has a high alkalinity (equivalent to KOH, for example) and a great foreign matter removal effect resulting from the etching action on glass, there is little increase in the roughness of the substrate surface after cleaning. Therefore, by cleaning the glass substrate using the cleaning liquid containing imidazole as the alkaline
15 cleaning agent, it is possible to realize a low roughness (high smoothness) of the glass substrate after cleaning, obtain good cleaning properties, and achieve high cleanliness.

[0032]

Although there is no particular limitation on the content of imidazole in
20 the cleaning liquid, it is preferable to set the content of imidazole to be in a range of 0.005 mol/L to 1 mol/L, for example. If the content of imidazole is less than 0.005 mol/L, an etching rate decreases, and therefore there is a risk that it will take time to obtain the foreign matter removal effect resulting from the etching action on glass, and the productivity deteriorates. On the other hand, if the
25 content of imidazole is greater than 1 mol/L, there is a risk that although sufficient alkaline cleaning action will be obtained, the rate of etching glass will increase excessively, and therefore roughness of the substrate surface after cleaning will increase dramatically.

[0033]

The above-described organic alkali agent such as guanidine or imidazole has a high solubility in water, exhibits strong alkalinity when dissolved in water, and has a great foreign matter removal effect resulting from etching
5 action on glass, but can suppress roughening on the surface resulting from etching. Although this mechanism is not necessarily clear, the following is conceivable.

That is, it is conceivable that if a potassium ion or a sodium ion binds to a OH group of the glass substrate surface (an external silanol group or an internal
10 silanol group produced by a siloxane bond (O-Si-O bond) being hydrolyzed), the etching rate of the bonded portion is selectively increased, and therefore variation in etching rate occurs on the glass substrate surface, leading to an increase in roughness, but even if the above-described organic alkali agent binds to the OH group of the glass surface, the etching rate does not increase.
15 Also, it is conceivable that the above-described organic alkali agent is first bound to the OH group, and thereby the effect of inhibiting Na ions and K ions from binding to the OH group thereafter can be obtained. Accordingly, by performing the cleaning processing while suppressing the content of sodium ions and potassium ions included in the cleaning liquid, an increase in the roughness of
20 the substrate surface after cleaning can be suppressed. Therefore, it is possible to realize very low roughness (high smoothness) of the glass substrate after cleaning, obtain good cleaning properties, and achieve high cleanliness.

[0034]

In the present invention, the abovementioned guanidine has better
25 effects than the abovementioned imidazole. It is inferred that this is because the abovementioned guanidine is a stronger base, and therefore the abovementioned guanidine has better effects of action.

It should be noted that a combination of the abovementioned guanidine and imidazole may be used in the present invention.

[0035]

Also, conventionally, it was generally thought that an increase in the roughness of the glass substrate surface after alkaline cleaning depends only on the alkalinity of an alkali agent, and that the stronger the alkali is, the more the roughness increases, but the inventors found that the increase amount of roughness is greatly influenced not only by the alkalinity of an alkali agent used in cleaning but also by the type of cation that is paired with the OH ion.

10 [0036]

For example, in the case where a strong alkali such as KOH or NaOH is used as the alkali agent, a foreign matter removal effect resulting from good etching action is obtained, but the roughness of the glass substrate surface after cleaning greatly increases. According to the studies of the inventors, it was found that in this case, not only the alkalinity of these alkali agents but also the presence of cations such as K ions and Na ions relates to an increase in the roughness of the substrate.

[0037]

In view of this, the inventors found that it is preferable to perform cleaning processing with the total amount of Na ions and K ions in the alkaline cleaning liquid being suppressed to less than 200 ppm. Accordingly, the etching action of OH ions of the alkali agent included in the cleaning liquid can be obtained, and by suppressing the amount of Na ions and K ions in the cleaning liquid, an increase in the roughness of a substrate resulting from the synergism of alkali metal ions and OH ions can be suppressed. In particular, it is preferable to perform cleaning processing with the total amount of Na ions and K ions in the alkaline cleaning liquid being suppressed to 100 ppm or less, more preferably 10 ppm or less, and even more preferably 1 ppm or less.

As a method for suppressing or controlling the content of sodium ions and potassium ions in the cleaning liquid, the cleaning liquid is sampled when cleaning is started or at a predetermined timing during cleaning to measure the content of these ions in the cleaning liquid, and in the case where the content of these ions exceeds a predetermined value, the content of these ions can be adjusted by reducing the content of these ions by means of addition of a chelating agent or the like that captures the above-described ions, dilution with water, replacement of the cleaning liquid, or the like. Also, in the case where the glass substrate contains Na or K, the relationship between a cleaning period or the number of batches (the number of cleaning processing) and the concentration of Na ions and K ions in the cleaning liquid is obtained in advance, and the processing for adjusting the content of Na ions and K ions may be performed based on the obtained relationship.

[0038]

It should be noted that it is conceivable that in the case where the abovementioned guanidine or imidazole is used, as described above, the influence of the presence of Na ions and K ions in the cleaning liquid decreases due to the properties of guanidine or imidazole binding to the OH group of the glass surface, and therefore the foreign matter removal effect resulting from good etching action can be obtained and an increase in the roughness of the substrate surface after cleaning can be suppressed.

[0039]

Also, in the case where a glass substrate containing alkali metal components such as sodium and potassium in the glass components is cleaned, it is preferable to perform a cleaning step with the total content of Na ions and K ions in the alkaline cleaning liquid being suppressed to less than 200 ppm.

It should be noted that the content of Na ions and K ions in the cleaning liquid can be checked using cleaning liquid sampled from a cleaning bath, by an ion chromatography method, or an ICP method, for example.

Also, ppm herein is mass ppm (mass ratio is expressed in parts per million).
[0040]

Also, in order to prevent foreign matter removed from the substrate surface by the alkaline cleaning agent from re-adhering to the substrate surface and to improve the cleaning effect, the cleaning liquid may appropriately contain cleaning agents such as a surfactant, a chelating agent, and a dispersant as well as the abovementioned guanidine or the abovementioned imidazole.

Examples of the surfactant that can be preferably used in the present invention include anionic surfactants such as sodium alkyl sulfates, fatty acid sodium, and alkyl aryl sulfonates, and nonionic surfactants such as polyoxyethylene alkyl ethers and polyoxyethylene derivatives. Also, examples of the chelating agent include aminocarboxylic acids such as EDTA, organic acids such as citric acid, and salts thereof. Moreover, examples of the dispersant include phosphates, sulfates, and polymeric dispersant.
[0041]

However, these cleaning agents such as a surfactant, a chelating agent, and a dispersant are usually prepared as alkaline salts (potassium salt, sodium salt, or the like), and therefore even in the case where the cleaning liquid contains these cleaning agents, it is preferable to perform the above-described cleaning processing with the total amount of sodium ions and potassium ions in the cleaning liquid being suppressed to less than 200 ppm. It is preferable to perform the above-described cleaning processing with the total amount thereof being suppressed to more preferably 100 ppm or less, and even more preferably 10 ppm or less. It should be noted that in such a case, a quaternary ammonium

cation such as a tetramethyl ammonium ion is preferably used to prepare quaternary ammonium salt. By preparing the quaternary ammonium salt, the addition amount can be increased without increasing the amount of sodium ions and potassium ions. Also, in the case where sodium and potassium are
5 inevitably mixed in as impurities in the synthesis of additive agents, it is preferable to use an additive agent that has undergone a purification treatment with an ion exchange resin such that the amount of these ions decreases. These are similarly applied to magnesium ions and calcium ions.

[0042]

10 Usually, the above-described cleaning processing is performed by bringing (immersing) a glass substrate that has been undergone a polishing step into contact with (in) a cleaning liquid containing at least one of the abovementioned guanidine and the abovementioned imidazole and a required additive agent in a cleaning bath. At this time, in order to improve the cleaning
15 effect, ultrasound is also preferably applied. The liquid temperature of the cleaning liquid, a cleaning period, or the like can be appropriately set.

[0043]

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

In other words, according to the present invention, an increase in the
25 roughness of a substrate surface resulting from alkaline cleaning can be suppressed.

[0044]

Also, it is preferable that the surface of the glass substrate immediately before the cleaning processing is a very smooth surface having a surface roughness (Ra) of 0.10 nm or less. According to the present invention, an increase in the roughness of the substrate surface resulting from alkaline cleaning can be suppressed, and therefore the above-described very smooth substrate surface roughness obtained by the polishing step can be prevented from deteriorating as much as possible.

[0045]

Also, in the present invention, the pH of the above-described cleaning liquid is preferably 10 or more. According to the present invention, even if the pH of the cleaning liquid is high (strong alkali), the roughness of the substrate surface increases slightly, as a result of which highly clean cleaning can be performed while an increase in roughness is suppressed. The pH of the cleaning liquid is more preferably set to 11 or more. If the pH thereof is less than 10, there are cases in which the etching rate decreases, and therefore it takes time to obtain the foreign matter removal effect resulting from the etching action on glass and the productivity deteriorates. On the other hand, if the pH is greater than 13, there are cases in which sufficient alkaline cleaning action can be obtained, but the etching rate increases due to alkali, and therefore in the case where the glass composition includes sodium and potassium, the elution amounts of sodium and potassium increase, as a result of which the need to frequently perform a process for adjusting sodium ions and potassium ions in the cleaning liquid arises. Also, there are cases in which variation occurs in the inner diameter or the outer diameter of the substrate, which needs very strict management, and the inner diameter or the outer diameter is out of a predetermined range. Also, the alkalinity increases excessively, and therefore the cleaning liquid needs to be handled with caution.

[0046]

A preferable embodiment of the present invention is a method for manufacturing a magnetic-disk glass substrate, including processing for cleaning a glass substrate. The cleaning processing includes processing for bringing the glass substrate into contact with a cleaning liquid containing at least one of guanidine and imidazole, a relationship between an increase amount of a surface roughness (Ra) of a main surface of the glass substrate after the cleaning processing with respect to a surface roughness (Ra) of the main surface of the glass substrate before the cleaning processing and a total concentration of sodium ions and potassium ions in a cleaning liquid that is used in the cleaning processing is obtained in advance. A total concentration of sodium ions and potassium ions in the cleaning liquid with which an increase amount of the surface roughness (Ra) reaches 0.06 nm or less is determined based on the obtained relationship. The cleaning processing is performed on the glass substrate having a main surface that is mirror-polished, under a condition that a total concentration of sodium ions and potassium ions in the cleaning liquid is the determined concentration or less.

According to such an embodiment, cleaning processing can be performed such that an increase amount of roughness of the glass substrate surface resulting from cleaning is a predetermined value or less.

[0047]

Also, another preferable embodiment of the present invention is a method for manufacturing a magnetic-disk glass substrate, in which the glass substrate contains at least one component of sodium and potassium in glass components, a cleaning liquid containing at least one of guanidine and imidazole is used, and the cleaning processing is performed on the glass substrate having a main surface that is mirror-polished, while at least a portion of the cleaning liquid is replaced when the total amount of sodium ions and potassium ions in the cleaning liquid exceeds 200 ppm.

[0048]

According to such an embodiment, even in the case where many glass substrates are cleaned successively and accordingly are cleaned in the same cleaning bath for a long period of time, when the total amount of sodium ions and potassium ions in the cleaning liquid exceeds 200 ppm, the cleaning liquid is replaced with a new cleaning liquid, and thereby the total amount of sodium ions and potassium ions in the cleaning liquid can be suppressed to 200 ppm or less, as a result of which an increase in the roughness of the glass substrate surface can be suppressed.

10 [0049]

Also, another preferable embodiment of the present invention is a method for manufacturing a magnetic-disk glass substrate, including processing for cleaning a glass substrate, and the cleaning processing includes processing for bringing the glass substrate into contact with a cleaning liquid containing at least one of guanidine and imidazole, and the cleaning processing is performed with the total amount of sodium ions and potassium ions in the cleaning liquid being suppressed to less than 200 ppm.

According to such an embodiment, the total amount of sodium ions and potassium ions in the cleaning liquid can be suppressed to less than 200 ppm, and therefore an increase in the roughness of the glass substrate surface can be suppressed.

[0050]

It should be noted that usually, in general, as described above, the polishing step is performed through two stages, namely, a first polishing step of removing scratches and distortion remaining from the lapping step and a second polishing step of finishing the surface roughness of the main surface of the glass substrate to a smooth mirror surface while maintaining a flat surface obtained in this first polishing step (however, multi-stage polishing having three stages or

more may be performed), and in this case, the cleaning processing of the present invention is preferably applied to a cleaning step that is performed after at least the second polishing step that is provided downstream, that is, the final polishing step of polishing steps. In particular, the cleaning processing of the present invention is preferable applied to cleaning processing performed after the polishing step of polishing a main surface of a glass substrate using a polishing liquid that contains colloidal silica polishing abrasive particles and is adjusted to be alkaline. In the case where polishing is performed on the glass substrate in an acidic condition, a portion of elements comes out from the surface of the glass substrate due to the leaching action of acid, whereafter etching is likely to be performed irregularly when alkaline cleaning is performed, resulting in an increase in roughening of the glass substrate surface after cleaning. Such a phenomenon is not observed in the case where polishing is performed under the condition that the polishing liquid is adjusted to be alkaline, and the roughness of the glass substrate surface can be relatively reduced.

[0051]

In the present invention, it is preferable that the (type of) glass constituting the glass substrate is aluminosilicate glass. Also, it is more preferable that the type of glass is amorphous aluminosilicate glass.

Mirror-polishing the surface of such a glass substrate yields a smooth mirror-finished surface, and the post-processing strength is favorable. Aluminosilicate glass containing SiO_2 in an amount of 58 wt% or more to 75 wt% or less, Al_2O_3 in an amount of 5 wt% or more to 23 wt% or less, Li_2O in an amount of 3 wt% or more to 10 wt% or less, and Na_2O in an amount of 4 wt% or more to 13 wt% or less as main components (it should be noted that aluminosilicate glass that does not contain phosphorus oxide) can be used as such aluminosilicate glass. Furthermore, it is possible to use phosphorus oxide-free amorphous aluminosilicate glass that contains as main components

SiO₂ in an amount of 62 wt% or more to 75 wt% or less, Al₂O₃ in an amount of 5 wt% or more to 15 wt% or less, Li₂O in an amount of 4 wt% or more to 10 wt% or less, Na₂O in an amount of 4 wt% or more to 12 wt% or less, and ZrO₂ in an amount of 5.5 wt% or more to 15 wt% or less, and has an Na₂O/ZrO₂ weight ratio of 0.5 or more to 2.0 or less and an Al₂O₃/ZrO₂ weight ratio of 0.4 or more to 2.5 or less, for example.

[0052]

In addition, there are cases in which heat resistance is required as a characteristic of a next-generation substrate. As heat resistant glass in this case, it is preferable to use, for example, glass that contains SiO₂ in an amount of 50 to 75 mol%, Al₂O₃ in an amount of 0 to 6 mol%, BaO in an amount of 0 to 2 mol%, Li₂O in an amount of 0 to 3 mol%, ZnO in an amount of 0 to 5 mol%, Na₂O and K₂O in a total amount of 3 to 15 mol%, MgO, CaO, SrO and BaO in a total amount of 14 to 35 mol%, and ZrO₂, TiO₂, La₂O₃, Y₂O₃, Yb₂O₃, Ta₂O₅, Nb₂O₅ and HfO₂ in a total amount of 2 to 9 mol%, and that has a molar ratio [(MgO+CaO)/(MgO+CaO+SrO+BaO)] in a range of 0.85 to 1 and a molar ratio [Al₂O₃/(MgO+CaO)] in a range of 0 to 0.30.

[0053]

In the present invention, the surface of the glass substrate after the polishing processing described above preferably has an arithmetic mean surface roughness Ra of 0.20 nm or less, particularly preferably 0.15 nm or less, and even more preferably 0.10 nm or less. Furthermore, the maximum roughness Rmax is preferably 2.0 nm or less, particularly preferably 1.5 nm or less, and even more preferably 1.0 nm or less. It should be noted that Ra and Rmax in the present invention refer to the roughness calculated in accordance with Japanese Industrial Standard (JIS) B0601: 1982. These surfaces are preferably mirror surfaces.

From a practical viewpoint, the surface roughness (a maximum roughness $R_{\max}$ and an arithmetic mean roughness R_a , for example) in the present invention is preferably the surface roughness of a surface shape that is measured using an atomic force microscope (AFM) in a range of $1\ \mu\text{m} \times 1\ \mu\text{m}$ at a resolution of 512×512 pixels.

[0054]

In the present invention, it is preferable to perform chemical strengthening before or after the polishing processing step. As a method for the chemical strengthening, it is preferable to use, for example, a

low-temperature ion-exchange method that performs ion exchange in a temperature range not exceeding the glass transition point, at a temperature from 300°C or more to 400°C or less. The chemical strengthening is processing in which the glass substrate is brought into contact with a molten chemical strengthening salt so that an alkali metal element having a relatively large atomic radius in the chemical strengthening salt and an alkali metal element having a relatively small atomic radius in the glass substrate are ion-exchanged, and thus the alkali metal element having a relatively large atomic radius permeates through the surface layer of the glass substrate, and compressive stress is generated on the surface of the glass substrate. A

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

[0055]

As shown in FIGS. 1 and 2, a disk-shaped glass substrate 1 having both main surfaces 11 and 11 with an outer circumferential side edge surface 12 and an inner circumferential side edge surface 13 therebetween can be obtained

with the method for manufacturing a magnetic-disk glass substrate of the present invention. The outer circumferential side edge surface 12 is constituted by a side wall surface 12a, and chamfered surfaces 12b and 12b that are each disposed between a main surface and the side wall surface 12a. The inner
5 circumferential side edge surface 13 also has a similar shape.

[0056]

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

[0057]

It is preferable to form a protective layer and a lubricant layer in this
25 order on the magnetic layer. An amorphous hydrogenated carbon-based protective layer is preferable as the protective layer. The protective layer can be formed by a plasma CVD method, for example. As the lubricant layer, a lubricant that has a functional group at the terminal of the main chain of a

perfluoropolyether compound can be used. In particular, it is preferable that the lubricant contains, as a main component, a perfluoropolyether compound that has a hydroxyl group as a polar functional group at the terminal. The lubricant layer can be applied and formed by a dipping method.

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

Working Examples

[0058]

- Hereinafter, the embodiment of the present invention will be described in
10 detail by way of working examples. It should be noted that the present invention is not limited to the following working examples. Also, comparative examples (reference examples) for the working examples of the present invention will be described.

- A magnetic-disk glass substrate was manufactured through (1) a rough
15 lapping step (rough grinding step), (2) a shape processing step, (3) a precision lapping step (precision grinding step), (4) an edge surface polishing step, (5) a main surface first polishing step, (6) a chemical strengthening step, (7) a main surface second polishing step, and (8) cleaning processing as described below.

[0059]

- 20 (1) Rough lapping step

- First, a disk-shaped glass substrate made of amorphous aluminosilicate glass and having a diameter of 66 mmφ and a thickness of 1.0 mm was obtained from molten glass by direct pressing using upper, lower, and drum molds. It should be noted that a glass substrate may be obtained by cutting plate glass
25 manufactured with a downdraw method or a float method other than using direct pressing into a predetermined size. Glass containing SiO₂ in an amount of 58 to 75 weight%, Al₂O₃ in an amount of 5 to 23 weight%, Li₂O in an amount of 3 to

10 weight%, and Na_2O in an amount of 4 to 13 weight% was used as this aluminosilicate glass.

[0060]

Next, in order to improve dimensional accuracy and shape accuracy, the lapping step was performed on this glass substrate. This lapping step was performed using a double-side lapping device. Specifically, the glass substrate held by a carrier was tightly placed between the upper and lower surface plates, and the glass substrate was lapped by the planet gear movement of the carrier through rotating the sun gear and the internal gear of the above-described lapping device.

[0061]

(2) Shape processing step

Next, a cylindrical grindstone was used to create a hole in the central portion of the glass substrate, and predetermined chamfering was then performed on an outer circumferential edge surface and an inner circumferential edge surface. It should be noted that in general, a magnetic disk having an outer diameter of 65 mm is used in a 2.5-inch HDD (hard disk drive).

[0062]

(3) Precision lapping step

This precision lapping step was performed using a double-side lapping device, similarly to the above. Specifically, the glass substrate held by the carrier was tightly placed between the upper and lower surface plates to which pellets in which diamond abrasive particles are fixed by a resin were attached.

[0063]

(4) Edge surface polishing step

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

[0064]

(5) Main surface first polishing step

Next, the first polishing step was performed using the above-described double-side polishing device shown in FIG 3. In the double-side polishing device, the glass substrate that is held by the carrier 4 is tightly placed between the upper and lower surface plates 5 and 6 to which the polishing pads 7 have been attached, the carrier 4 is engaged with the sun gear 2 and the internal gear 3, and the glass substrate is pressed between the upper and lower surface plates 5 and 6. Then, a polishing liquid is supplied between the polishing pads and the glass substrate surfaces to be polished, the upper and lower surface plates 5 and 6 are rotated, and thus the glass substrate revolves while rotating on the surface plates 5 and 6 so that both surfaces of the glass substrate are polished simultaneously. Specifically, the first polishing step was performed using a hard polisher (hard urethane foam) as a polisher. A polishing liquid in which 10 weight% cerium oxide (average particle diameter (50% diameter) of 1 μm) was dispersed in water as an abrasive was used as the polishing liquid. The load that was applied to the glass substrate surface was set to 100 g/cm^2 and a polishing period was set to 15 minutes.

After undergoing the first polishing step, the glass substrate was cleaned and dried.

[0065]

(6) Chemical strengthening step

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

dried in the heated chemical strengthening liquid. The glass substrate that had undergone the chemical strengthening was cleaned and dried.

[0066]

(7) Main surface second polishing step

5 Next, the second polishing step was performed using the same double-side polishing device as used in the above-described first polishing step, but polishing pads (polyurethane foam having an Asker C hardness of 72) with a soft polisher (suede) were used as the polisher. This second polishing step is mirror-polishing processing to finish the main surfaces of the glass substrate into
10 smooth mirror surfaces having a surface roughness $R_{\max}$ of about 2 nm or less, for example, while maintaining the flat surfaces obtained in the first polishing step described above. A liquid in which 10 weight% colloidal silica (having an average particle diameter (50% diameter) of 15 nm) was dispersed in water as an abrasive and sulfuric acid was added thereto to adjust the solution to be
15 acidic (pH=2) was used as the polishing liquid. It should be noted that the load was set to 100 g/cm^2 and a polishing period was set to 10 minutes.

It should be noted that in order to check the surface roughness R_a after polishing, one substrate was removed from the same lot, only aqueous cleaning was performed for 1200 seconds, and the substrate was dried, and when the
20 surface roughness was measured with the AFM under the above-described conditions, the R_a was 0.15 nm. However, many colloidal silica particles adhered to the substrate surface and this substrate was not acceptable as the product.

[0067]

25 (8) Cleaning processing

Next, processing for cleaning the glass substrate that had undergone the above-described second polishing step was performed. Specifically, the glass substrate was immersed in a cleaning liquid (pH=12.6) obtained by adding

guanidine as an alkaline cleaning agent to pure water such that the concentration of guanidine was 0.3 mol/L for 600 seconds in a cleaning bath (liquid temperature: room temperature), and the glass substrate was cleaned by applying 80 kHz ultrasound thereto. It should be noted that the cleaning liquid was used cyclically.

At this time, guanidine that did not contain Na ions or K ions (detection limit or less) was used. It should be noted that when this cleaning liquid was sampled and the concentration of Na ions and K ions was checked with an ion chromatography method, neither Na ions nor K ions were detected.

Thereafter, the glass substrate was placed in another cleaning bath (pure water, room temperature), and ultrasound cleaning was performed at 80 kHz for 300 seconds, and the substrate was dried.

[0068]

With regard to 100 glass substrates (Sample 1) obtained through the above-described steps, the surface roughnesses (Ra) of the main surfaces of the glass substrates after the above-described cleaning processing and the surface roughnesses (Ra) of the main surfaces of the glass substrates immediately before the above-described cleaning processing (that is, after the second polishing step ended) were measured with an atomic force microscope (AFM), and the difference (ΔRa : a value obtained by subtracting the Ra before the cleaning processing from the Ra after the cleaning processing) is shown in Table 1. It should be noted that the value of the above-described surface roughness is the average value of the 100 glass substrates that were manufactured.

Also, evaluation of foreign matter defects was performed on another 100 glass substrates that were obtained under the same conditions. The main surfaces of the obtained glass substrates were observed with a laser-type surface inspection device, and the detected surface defects were analyzed with

a SEM and an atomic force microscope (AFM). The count number of foreign matter defects (protrusion defects resulting from foreign matter adherence) is then shown in Table 2. It should be noted that the above-describe count number is an average value of the 100 glass substrates that were manufactured.

5 It should be noted that by irradiating the main surface with laser light having a wavelength of 405 nm, a power of 80 mW, and a spot diameter of 6 μm under the measurement conditions for the surface inspection device, extremely minute defects having a length in the main surface direction of about 10 to 40 nm can also be observed.

10 In Sample 1 above, a magnetic-disk glass substrate having a substrate surface in which an increase in the substrate surface roughness resulting from alkaline cleaning was suppressed to 0.06 nm or less was obtained.

[0069]

Also, glass substrates of Samples 2 to 6 were produced, similarly to
15 Sample 1 above, except that cleaning liquids that had various different addition amounts of KOH and guanidine and that had the alkali metal ion concentrations in the cleaning liquid shown in Table 1 were used. It should be noted that in the case where the pH was not 12.6, the addition amount of guanidine was slightly adjusted so that the pH was 12.6.

20 Also, glass substrates of Samples 7 to 10 were produced, similarly to Sample 1 above, except that cleaning liquids that had various different addition amounts of tetramethylammonium hydroxide (abbreviated to "TMAH" hereinafter) added as the alkali agent and that had the alkali metal ion concentrations in the cleaning liquid shown in Table 1 were used.

25 Also, glass substrates of Samples 11 and 12 were produced, similarly to Sample 1 above, except that cleaning liquids obtained by adding KOH or NaOH that is the conventional inorganic alkali agent to cleaning liquids were used.

[0070]

Furthermore, glass substrates of Samples 13 to 17 were produced, similarly to Sample 1 above, except that cleaning liquids that had various different addition amounts of the anion surfactant (tetramethylammonium dodecylbenzene sulfonate (quaternary ammonium cation salt), abbreviated to DBS hereinafter) added in addition to guanidine as the cleaning agent, and that had the alkali metal ion concentrations in the cleaning liquid shown in Table 1 were used. Also, a glass substrate of Sample 18 was produced, similarly to Sample 1 above, except that a cleaning liquid to which poly(oxyethylene) nonylphenyl ether having a molecular weight of 660.87 (10E0) (10E0 indicates that the addition mole number of ethylene oxide is 10) was added in addition to guanidine as the cleaning agent, and that had the alkali metal ion concentration in the cleaning liquid shown in Table 1 was used.

It should be noted that in Samples 1 to 18 above, the alkali metal ion concentration in the cleaning liquid was adjusted with Na ions or K ions. Even in the case where a predetermined alkali metal ion concentration was adjusted by mixing Na ions and K ions, a result that is substantially same as those of Tables 1 and 2 below was obtained, and therefore the result does not depend on the mixing ratio of Na ions and K ions.

[0071]

With regard to the glass substrates of Samples 2 to 18 above, similarly to Sample 1, the surface roughnesses of the main surfaces were measured and foreign matter defects were evaluated, and the results are shown collectively in Tables 1 and 2 below.

[0072]

[Table 1]

		Alkali metal ion concentration in cleaning liquid (ppm)	ΔRa (nm)
Sample 1	guanidine	0	0.005
Sample 2	guanidine	1	0.007
Sample 3	guanidine	10	0.010
Sample 4	guanidine	95	0.033
Sample 5	guanidine	195	0.060
Sample 6	guanidine	210	0.065
Sample 7	TMAH	0	0.006
Sample 8	TMAH	1	0.008
Sample 9	TMAH	10	0.011
Sample 10	TMAH	95	0.035
Sample 11	KOH	12000	0.070
Sample 12	NaOH	12000	0.070
Sample 13	guanidine+additive agent (DBS)	0	0.005
Sample 14	guanidine+additive agent (DBS)	1	0.007
Sample 15	guanidine+additive agent (DBS)	10	0.010
Sample 16	guanidine+additive agent (DBS)	95	0.033
Sample 17	guanidine+additive agent (DBS)	195	0.060
Sample 18	guanidine+additive agent (nonionic surfactant)	1	0.007

[0073]

[Table 2]

		Foreign matter defect evaluation (count number)
Sample 1	guanidine	798
Sample 2	guanidine	795
Sample 3	guanidine	782
Sample 4	guanidine	770
Sample 5	guanidine	765
Sample 6	guanidine	747
Sample 7	TMAH	853
Sample 8	TMAH	850
Sample 9	TMAH	842
Sample 10	TMAH	836
Sample 13	guanidine+additive agent (DBS)	430
Sample 14	guanidine+additive agent (DBS)	427
Sample 15	guanidine+additive agent (DBS)	394
Sample 16	guanidine+additive agent (DBS)	372
Sample 17	guanidine+additive agent (DBS)	384
Sample 18	guanidine+additive agent (nonionic surfactant)	424

5 [0074]

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

1. According to Working Examples in which the cleaning liquid of the present invention that contains guanidine is applied, an increase in the roughness of a substrate surface after cleaning processing can be suppressed.

10 Also, even if the above-described surfactant is added thereto in addition to

guanidine, an increase amount of roughness after the cleaning processing does not change, but the cleaning properties are improved.

2. In contrast to this, in the case where cleaning is performed with conventional KOH or NaOH, good cleaning properties are obtained, but there is
5 a significant increase in the roughness of a substrate surface after the cleaning processing. Also, if TMAH is added, the increase amount of roughness is slightly larger compared to guanidine, and the count number of foreign matter defects also increases slightly.

It should be noted that the foreign matter count numbers in Sample 11
10 (KOH) and Sample 12 (NaOH) above were respectively 775 and 796. Although this result is equivalent to the result of guanidine, there is a significant increase in roughness after the cleaning processing as described above, and therefore it is not possible to achieve both the suppression of an increase in roughness resulting from cleaning and the improvement of the cleaning properties.

15 3. Also, guanidine is more preferably used as the alkali agent than TMAH because guanidine can reduce an increase amount of roughness of a surface. As described above, it is conceivable that guanidine has the effect of being adsorbed by a silanol group of a glass substrate surface and suppressing Na ions and K ions from coming close to the silanol group, and therefore
20 guanidine has a higher effect of suppressing an increase in roughness than TMAH.

The fact that guanidine is advantageous was further checked. When cleaning tests were performed in succession on 20 batches under the conditions of Sample 1 and Sample 7, and the values of ΔRa of glass substrates in the 20th
25 batches were compared with the values of ΔRa in the first batches, the values of ΔRa of the 20th batches increased compared to those of the first batches, but in the 20th batches, the ΔRa that was obtained with guanidine was smaller than the ΔRa that was obtained with TMAH. Both values of ΔRa were substantially the

same in the comparison in the result of the first batches (Table 1), and therefore it is conceivable that an increase in roughness was suppressed due to the action of guanidine.

Also, when glass substrates were produced under conditions that were
5 the same as in Sample 1 except that the pH of the polishing liquid was adjusted to be alkaline (pH 12) in the main surface second polishing step, the ΔRa decreased to 70% of the ΔRa that was obtained in the case of Sample 1. Based on this, the pH of the polishing liquid that is used in the polishing processing before the cleaning processing of the present invention is performed
10 is more preferably alkaline than acidic.
[0075]

Also, glass substrates of Samples 101 to 106 were produced, similarly to Sample 1 above, except that cleaning liquids that had various different addition amounts of imidazole and that had the alkali metal ion concentrations in the
15 cleaning liquid shown in Table 3 were used.

Also, glass substrates of Samples 107 to 110 were produced, similarly to Sample 101 above, except that cleaning liquids that had various different amounts of tetramethylammonium hydroxide (abbreviated to "TMAH" hereinafter) added as the alkali agent, and that had the alkali metal ion
20 concentrations in the cleaning liquid shown in Table 3 were used.

Also, glass substrates of Samples 111 and 112 were produced, similarly to Sample 101 above, except that cleaning liquids obtained by adding KOH or NaOH that is the conventional inorganic alkali agent to cleaning liquids were used.
25 [0076]

Furthermore, glass substrates of Samples 113 to 117 were produced, similarly to Sample 101 above, except that cleaning liquids that had various different addition amounts of the abovementioned DBS added in addition to

imidazole as the cleaning agent and that had the alkali metal ion concentrations shown in Table 3 were used. Also, a glass substrate of Sample 118 was produced, similarly to Sample 101 above, except that a cleaning liquid to which the above-described nonionic surfactant was added in addition to guanidine as
5 the cleaning agent, and that had the alkali metal ion concentration in the cleaning liquid shown in Table 3 was used.

[0077]

Similarly to Sample 1, with regard to the glass substrates of Samples 101 to 118 above, the surface roughnesses of the main surfaces were measured
10 and foreign matter defects were evaluated, and the results are collectively shown in Tables 3 and 4 below.

[0078]

[Table 3]

		Alkali metal ion concentration in cleaning liquid (ppm)	ΔRa (nm)
Sample 101	imidazole	0	0.003
Sample 102	imidazole	1	0.003
Sample 103	imidazole	10	0.005
Sample 104	imidazole	95	0.017
Sample 105	imidazole	195	0.033
Sample 106	imidazole	290	0.065
Sample 107	TMAH	0	0.006
Sample 108	TMAH	1	0.008
Sample 109	TMAH	10	0.011
Sample 110	TMAH	95	0.035
Sample 111	KOH	12000	0.070
Sample 112	NaOH	12000	0.070
Sample 113	imidazole+additive agent (DBS)	0	0.003
Sample 114	imidazole+additive agent (DBS)	1	0.003
Sample 115	imidazole+additive agent (DBS)	10	0.005
Sample 116	imidazole+additive agent (DBS)	95	0.017
Sample 117	imidazole+additive agent (DBS)	195	0.033
Sample 118	imidazole+additive agent (nonionic surfactant)	1	0.007

[0079]

[Table 4]

		Foreign matter defect evaluation (count number)
Sample 101	imidazole	1184
Sample 102	imidazole	1150
Sample 103	imidazole	1102
Sample 104	imidazole	1045
Sample 105	imidazole	1011
Sample 106	imidazole	987
Sample 113	imidazole+additive agent (DBS)	830
Sample 114	imidazole+additive agent (DBS)	815
Sample 115	imidazole+additive agent (DBS)	783
Sample 116	imidazole+additive agent (DBS)	792
Sample 117	imidazole+additive agent (DBS)	778
Sample 118	imidazole+additive agent (nonionic surfactant)	811

5 [0080]

The following can be found from the results of Tables 3 and 4 above.

1. According to working examples in which the cleaning liquid of the present invention that contains imidazole was applied, an increase in the roughness of a substrate surface after the cleaning processing can be suppressed. Also, even if the above-described surfactant is added in addition to imidazole, an increase amount of roughness after the cleaning processing does not change, and the cleaning properties are improved.

2. In contrast to this, in the case where cleaning is performed with conventional KOH or NaOH, good cleaning properties are obtained, but there is

a significant increase in the roughness of a substrate surface after the cleaning processing. Also, if TMAH is added, the increase amount of roughness is slightly larger compared to guanidine, and the count number of foreign matter defects also increases slightly.

5 [0081]

(Manufacturing magnetic disk)

A magnetic disk for perpendicular magnetic recording was manufactured by performing the following film forming step on the magnetic-disk glass substrates obtained in Samples 1 and 101.

10 Specifically, an adherent layer constituted by a CrTi-based alloy thin film, a soft magnetic layer constituted by a CoTaZr alloy thin film, a seed layer constituted by NiW, a base layer constituted by a Ru thin film, a perpendicular magnetic recording layer made of a CoCrPt-based alloy, a carbon protective layer, and a lubricant layer were sequentially formed on the glass substrate.

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

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

25

Description of Reference Numerals

[0082]

1 Glass substrate

	2	Sun gear
	3	Internal gear
	4	Carrier
	5	Upper surface plate
5	6	Lower surface plate
	7	Polishing pad
	11	Main surface of substrate
	12, 13	Edge surface of substrate

CLAIMS

1. A method for manufacturing a magnetic-disk glass substrate,
comprising processing for cleaning a glass substrate, wherein

the cleaning processing includes processing for bringing the glass
5 substrate into contact with a cleaning liquid containing at least one of guanidine
and imidazole,

a relationship between an increase amount of a surface roughness (Ra)
of a main surface of the glass substrate after the cleaning processing with
respect to the surface roughness (Ra) of the main surface of the glass substrate
10 before the cleaning processing and a total concentration of sodium ions and
potassium ions in a cleaning liquid that is used in the cleaning processing is
obtained in advance,

a total concentration of sodium ions and potassium ions in the cleaning
liquid with which an increase amount of the surface roughness (Ra) reaches
15 0.06 nm or less is determined based on the obtained relationship, and

the cleaning processing is performed on the glass substrate having a
main surface that is mirror-polished, under a condition that a total concentration
of sodium ions and potassium ions in the cleaning liquid is the determined
concentration or less.

20 2. A method for manufacturing a magnetic-disk glass substrate,
comprising processing for cleaning a glass substrate, wherein

the glass substrate contains at least one component of sodium and
potassium in glass components,

a cleaning liquid containing at least one of guanidine and imidazole is
25 used, and

the cleaning processing is performed on the glass substrate having a
main surface that is mirror-polished, while at least a portion of the cleaning liquid

is replaced such that a total amount of sodium ions and potassium ions in the cleaning liquid does not reach 200 ppm or more.

3. A method for manufacturing a magnetic-disk glass substrate, comprising processing for cleaning a glass substrate, wherein

5 the cleaning processing includes processing for bringing the glass substrate into contact with a cleaning liquid containing at least one of guanidine and imidazole, and

the cleaning processing is performed with a total amount of sodium ions and potassium ions in the cleaning liquid being suppressed to less than 200
10 ppm.

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

the glass substrate contains at least one component of sodium and potassium in glass components.

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

the cleaning liquid further contains at least one of a surfactant, a chelating agent, and a dispersant, and

the cleaning processing is performed with a total amount of sodium ions and potassium ions in the cleaning liquid being suppressed to less than 200
20 ppm.

6. The method for manufacturing a magnetic-disk glass substrate according to any of claims 2 to 5, wherein

a difference between a surface roughness (Ra) of the main surface of
25 the glass substrate after the cleaning processing and the surface roughness (Ra) of the main surface of the glass substrate immediately before the cleaning processing is 0.06 nm or less.

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

the cleaning processing is cleaning processing that is performed after a final polishing step among polishing steps of polishing the main surface of the glass substrate with polishing abrasive particles.

8. The method for manufacturing a magnetic-disk glass substrate according to claim 7, wherein

a polishing liquid that is used in the final polishing is alkaline.

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