

DESCRIPTION

Title of Invention

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

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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 apparatus 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 provided
15 in magnetic disk apparatuses 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 magnetic disk can be made
20 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 at lower cost has been increasing, and in order to achieve this, further
25 quality improvement and cost reduction of magnetic-disk glass substrates are also
required.

[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. In order to produce such a glass substrate, an extremely highly smooth main surface has been achieved by performing grinding to adjust the thickness and to improve the flatness (planeness), and by then further performing polishing processing to reduce surface roughness and minute waviness.

[0004]

Incidentally, a grinding method with fixed abrasive particles that uses a diamond pad in a grinding step (Patent Literature 1, for example) in which loose abrasive particles were used conventionally has been proposed (Patent Literature 2 and Patent Literature 3, for example). A diamond pad is a sheet on which diamond particles or aggregates consisting of some diamond particles held together with a binder such as glass, ceramic, a metal or a resin are fixed by using a supporting material such as a resin (e.g., acrylic resin). Alternatively, a diamond pad may also be obtained by forming a resin layer containing diamond particles on a sheet and then forming grooves in the resin layer to form projections. It should be noted that although the term "diamond pad" used here is not necessarily in common usage, "diamond pad" will be used herein for the sake of convenience.

[0005]

With conventional loose abrasive particles, abrasive particles with uneven shapes are present non-uniformly between the surface plate and the glass sheet, and thus the load applied to the abrasive particles is not uniform. If the load is concentrated in certain areas, deep cracks form in the glass sheet because the elasticity of the surface of the cast-iron surface plate is poor. Accordingly, deeper layers are affected and the roughness of the processed glass surface increases, requiring large amounts of glass to be removed in the subsequent mirror-polishing

step, and thus making it difficult to reduce processing costs. In contrast, in grinding with fixed abrasive particles using a diamond pad, the abrasive particles are uniformly present on the sheet surface, and thus the load is not concentrated in certain areas. In addition, the abrasive particles are fixed to the sheet using a resin, and therefore, even when a load is applied to the abrasive particles, cracks in the processed surface are shallow (shallow layers are affected) due to the highly elastic nature of the resin that fixes the abrasive particles. Thus, the roughness of the processed surface can be reduced, the load (e.g., machining allowance) on subsequent steps is reduced, and processing cost can be reduced.

After this grinding step, mirror-polishing is performed to obtain a high precision flat surface.

Prior Art Document(s)

Patent Literature(s)

[0006]

Patent Literature 1: JP 2001-6161 A

Patent Literature 2: JP 2012-43492 A

Patent Literature 3: JP 2009-99249 A

Patent Literature 4: JP 2003-534137 A

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Summary of Invention

Problem to be solved by the Invention

[0007]

As described above, with the grinding method with fixed abrasive particles using a diamond pad, the roughness of the processed surface can be reduced, the load on the subsequent mirror-polishing step is reduced, and the processing cost of glass substrates can be reduced. However, investigations conducted by the inventors of the present invention revealed the following problems.

Conventionally, in the grinding with fixed abrasive particles, the density of the fixed abrasive particles has been increased in order to increase the grinding speed (see Patent Literature 2). However, as a result of the investigations conducted by the inventors of the present invention, it was revealed that there was
5 a case where the processing speed could not be increased by merely increasing the density of the fixed abrasive particles. Moreover, it was revealed that the processing speed varied even when the diamond pads having the same density of abrasive particles were used.

[0008]

10 The inventors of the present invention investigated the causes for these. As a result, it was revealed that there were cases where the dispersion state of the fixed abrasive particles in the pellets deteriorated when the density of the fixed abrasive particles was changed, the load applied to the fixed abrasive particles was not uniform at that time, and thus the processing did not progress particularly in an
15 early stage of the processing, resulting in a decrease in the processing speed. In particular, when the grinding with fixed abrasive particles using a diamond pad is directly performed on a glass plate manufactured with a float method or the like, diamond abrasive particles have difficulty cutting into the substrate surface and tend to slide over the surface in the early stage of the processing because the glass
20 substrate surface is a so-called mirror-finished surface at the start of the processing, thus resulting in a period of time (dead time) during which no grinding is performed. Therefore, the above-mentioned problems arise significantly. Moreover, the dispersion states may be different even when the densities of the abrasive particles are the same, and thus the processing speed may be affected.

25 [0009]

The present invention was made in order to solve the foregoing conventional problems, and an object of the present invention is to provide a method for manufacturing a magnetic-disk glass substrate that can increase the

processing speed and enables stable grinding to be performed when grinding with fixed abrasive particles is performed, and according to which a high-quality glass substrate can be manufactured, and a method for manufacturing a magnetic disk using the glass substrate obtained by the above method.

5

Means to Solve the Problem

[0010]

As a result of carrying out intensive research to solve the foregoing problems, the inventors of the present invention found that there was a correlation between the average inter-abrasive-particle distance in a grindstone with fixed abrasive particles and the processing speed obtained when a glass substrate was ground using the grindstone with fixed abrasive particles. Therefore, they found that it was possible to increase the processing speed and perform stable grinding by determining such a correlation in advance, selecting, based on the determined correlation, a grindstone with fixed abrasive particles having an average inter-abrasive-particle distance with which a desired processing speed can be obtained, and using the selected grindstone with fixed abrasive particles. They also found that such a method is particularly suitable for grinding performed on a glass substrate whose main surface is a mirror-finished surface.

Specifically, in order to solve the foregoing problems, the present invention includes the following aspects.

[0011]

(Aspect 1)

An aspect of the present invention is a method for manufacturing a magnetic-disk glass substrate including performing grinding processing for grinding a main surface of a glass substrate using a lubricant and a surface plate having a grinding surface provided with a grindstone with fixed abrasive particles, wherein the grindstone with fixed abrasive particles includes fixed abrasive particles

contained in a supporting material, a correlation between an average inter-abrasive-particle distance of the fixed abrasive particles on the grinding surface of the grindstone with fixed abrasive particles and a processing speed obtained when the glass substrate is ground using the grindstone with fixed abrasive particles is determined in advance, and a grindstone with fixed abrasive particles having an average inter-abrasive-particle distance with which a desired processing speed can be obtained is selected based on the determined correlation, and the grinding processing is performed using the selected grindstone with fixed abrasive particles.

10 [0012]

(Aspect 2)

Another aspect of the present invention is a method for manufacturing a magnetic-disk glass substrate including performing grinding processing for grinding a main surface of a glass substrate using a lubricant and a surface plate having a grinding surface provided with a grindstone with fixed abrasive particles, wherein the grindstone with fixed abrasive particles includes fixed abrasive particles contained in a supporting material, and the fixed abrasive particles have an average inter-abrasive-particle distance of 80 μm to 200 μm on the grinding surface of the grindstone with fixed abrasive particles.

20 [0013]

(Aspect 3)

In the method for manufacturing a magnetic-disk glass substrate according to aspect 1, the average inter-abrasive-particle distance is 80 μm to 200 μm .

(Aspect 4)

25 In the method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 3, the fixed abrasive particles have an average particle diameter of 15 μm to 50 μm .

[0014]

(Aspect 5)

In the method for manufacturing a magnetic-disk glass substrate according to aspects 1 to 4, the fixed abrasive particles include diamond abrasive particles.

(Aspect 6)

5 In the method for manufacturing a magnetic-disk glass substrate according to aspects 1 to 5, the fixed abrasive particles are constituted by abrasive particles or abrasive aggregates consisting of a plurality of abrasive particles held together with a binder.

[0015]

10 (Aspect 7)

In the method for manufacturing a magnetic-disk glass substrate according to aspects 1 to 6, the main surface of the glass substrate is a mirror-finished surface at a start of the grinding processing.

(Aspect 8)

15 In the method for manufacturing a magnetic-disk glass substrate according to aspects 1 to 7, a processing load is 50 g/cm² to 200 g/cm².

[0016]

(Aspect 9)

20 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 8.

Effect of the Invention

25 [0017]

With the present invention, the conventional problems can be solved with the above-mentioned configurations, and it is possible to increase the processing speed and perform stable grinding when grinding with fixed abrasive particles is

performed. Moreover, this makes it possible to manufacture a high-quality glass substrate at low cost. Furthermore, it is possible to obtain a highly reliable magnetic disk using the glass substrate obtained thereby.

5 Brief Description of Drawings

[0018]

FIG. 1 is a schematic cross-sectional view showing an example of a configuration of a grindstone with fixed abrasive particles (diamond pad).

FIG. 2 is a schematic view for illustrating a state during grinding.

10 FIG. 3 is a diagram showing examples of measurement positions of an average inter-abrasive-particle distance on a grindstone with fixed abrasive particles.

FIG. 4 is a diagram showing a relationship between an average inter-abrasive-particle distance and a grinding rate.

15

Description of Embodiments

[0019]

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

20 A magnetic-disk glass substrate is usually manufactured through a shape processing step, a grinding step, an edge surface polishing step, a main surface polishing step, a chemical strengthening step, and the like.

In a method for manufacturing a magnetic-disk glass substrate according to the present invention, a glass substrate is obtained by cutting a sheet of glass that
25 has been manufactured with a float method or a down draw method into a glass substrate having a predetermined size. Alternatively, a glass substrate that is manufactured by pressing molten glass may also be used. The present invention is suitable for a case where a glass substrate whose main surface is a

mirror-finished surface at the start of grinding is used.

[0020]

Next, this glass substrate is ground to improve the dimensional accuracy and shape accuracy. In this grinding, 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 manner, the substrate is processed so as to have a predetermined thickness and flatness, and a predetermined surface roughness is obtained.

[0021]

10 The present invention relates to an improvement of this grinding. The grinding processing in the present invention is grinding that uses fixed abrasive particles including diamond particles, for example, and in a double-side grinding apparatus, a glass substrate that is held by a carrier is tightly placed between upper and lower surface plates to which diamond pads serving as grindstones with fixed
15 abrasive particles are attached, for example, then the glass substrate and the upper and lower surface plates are moved relative to each other while the glass substrate is pressed by the upper and lower surface plates at a predetermined pressure, and thus both main surfaces of the glass substrate are ground simultaneously. At this time, a lubricant (coolant) is supplied in order to cool the
20 processed surfaces and promote processing.

[0022]

As the grindstone with fixed abrasive particles used in the present invention, a diamond pad can be used, for example, and an outline of the configuration thereof is shown in FIG. 1. In a diamond pad 1 shown in FIG. 1, abrasive
25 aggregates 2 (sometimes also called assembled abrasive particles or aggregated abrasive particles) consisting of a plurality of diamond particles 4 (see FIG. 2) held together with a binder such as glass, ceramic, a metal or a resin are fixed by using a supporting material 3 such as a resin (e.g., acrylic resin). It should be

understood that the configuration shown in FIG. 1 is merely an example, and the present invention is not to be construed as being limited thereto. For example, a diamond pad obtained by forming a resin layer containing aggregates including diamond abrasive particles on a sheet and then forming grooves in the resin layer

5 may also be used. Moreover, a diamond pad obtained by dispersing not the above-mentioned abrasive aggregates but only diamond particles as they are in the supporting material may also be used.

[0023]

It is possible to manufacture diamond pads that differ in the particle
10 diameter (average particle diameter) and the abrasive density of the above-mentioned aggregates. It should be noted that in this embodiment, unless otherwise stated, the terms "fixed abrasive particles" and merely "abrasive particles" mean the above-mentioned aggregates, and the terms "average particle diameter" and "abrasive density" of fixed abrasive particles respectively mean the
15 average particle diameter and the abrasive density of the above-mentioned aggregates.

[0024]

As described in aspect 1 above, the grinding processing in the present invention is grinding processing for grinding a main surface of a glass substrate
20 using a lubricant and a surface plate having a grinding surface provided with a grindstone with fixed abrasive particles, wherein the grindstone with fixed abrasive particles includes fixed abrasive particles contained in a supporting material, a correlation between an average inter-abrasive-particle distance of the fixed abrasive particles on the grinding surface of the grindstone with fixed abrasive
25 particles and a processing speed obtained when the glass substrate is ground using the grindstone with fixed abrasive particles is determined in advance, and a grindstone with fixed abrasive particles having an average inter-abrasive-particle distance with which a desired processing speed can be obtained is selected based

on the determined correlation, and the grinding processing is performed using the selected grindstone with fixed abrasive particles.

[0025]

As described above, conventionally, even if grindstones with fixed abrasive
5 particles in which the abrasive densities and the particle diameters of the abrasive
particles were the same were used, the processing speed varied depending on the
dispersion state of the abrasive particles, and thus stable grinding performance
could not be obtained. In short, at present, it is not possible to judge the grinding
performance of a grindstone with fixed abrasive particles such as a diamond pad
10 until the grindstone is actually used. One of the reasons for this is that the
abrasive particles and the resin significantly differ in the physical properties due to
differences in the materials thereof, thus making it relatively difficult to achieve
uniform dispersion in the manufacturing process, for example.

[0026]

15 As a result of carrying out intensive research to solve the problems of the
conventional techniques, the inventors of the present invention found that there
was a correlation between the average inter-abrasive-particle distance of fixed
abrasive particles on the grinding surface of a grindstone with fixed abrasive
particles and the processing speed obtained when a glass substrate was ground
20 using the grindstone with fixed abrasive particles. Accordingly, such a correlation
is determined in advance, and a grindstone with fixed abrasive particles having an
average inter-abrasive-particle distance with which a desired processing speed can
be obtained is selected based on the determined correlation. By selecting and
using this grindstone with fixed abrasive particles having a predetermined average
25 inter-abrasive-particle distance, it is possible to increase the processing speed and
obtain stable grinding performance. Therefore, it is possible to increase the
processing speed and perform stable grinding.

In short, it is possible to stabilize and increase the processing speed in the

grinding by using a grindstone with fixed abrasive particles in which the inter-abrasive-particle distances of the fixed abrasive particles are appropriately controlled on the surface (grinding processing surface) of the grindstone with fixed abrasive particles. Moreover, the present invention is particularly suitable for grinding performed on a glass substrate whose main surface is a mirror-finished surface.

[0027]

In the present invention, the average inter-abrasive-particle distance in a grindstone with fixed abrasive particles is a value determined as follows.

(1) The surface (grinding surface) of a grindstone with fixed abrasive particles such as a diamond pad is observed under a scanning electron microscope (SEM).

(2) In the present invention, a rectangular region of $1.25\text{ mm} \times 0.825\text{ mm}$ ($=1.03\text{ mm}^2$) serves as a measurement range.

[0028]

It should be noted that the above-mentioned measurement range is merely an example, and a measurement range is determined such that 15 or more fixed abrasive particles are present in one measurement range. Although details will be described later, this makes it possible to stably calculate the average inter-abrasive-particle distance since the average inter-abrasive-particle distance is calculated by determining and averaging a plurality of values.

If less than 15 fixed abrasive particles are present in the set measurement range, another measurement range is set. It should be noted that when the number of fixed abrasive particles is counted, the diameters of the fixed abrasive particles are determined by approximating each fixed abrasive particle with a circle, and out of the fixed abrasive particles observed in the measurement range, only the number of the fixed abrasive particles whose diameter is larger than the average particle diameter (D50) of the fixed abrasive particles is counted. It is sufficient

that the average particle diameter of the fixed abrasive particles is determined in advance. The reason for focusing on the fixed abrasive particles having a particle diameter that is larger than the average particle diameter and counting the number thereof is that abrasive particles other than those abrasive particles contribute
5 extremely little to the grinding. That is, the reason is that fixed abrasive particles that project from the grinding surface in a small projecting amount due to most of the fixed abrasive particle burying in the grindstone, and abrasive particles whose size itself is small contribute extremely little to the processing. If the number of these fixed abrasive particles is also counted, there is a risk that a correlation with
10 the processing rate cannot be obtained.

[0029]

It should be noted that in the present invention, the above-mentioned average particle diameter (D50) denotes a particle diameter (referred to as "cumulative average particle diameter (50% diameter)" hereinafter) at which a
15 cumulative curve reaches 50% when the cumulative curve is determined by setting the total volume of powder particles in the particle size distribution measured with a laser diffraction method to 100%. Specifically, the cumulative average particle diameter (50% diameter) is a value that can be measured using a particle diameter/particle size distribution measurement apparatus or the like.

20 [0030]

It is desirable that a plurality of measurement positions are provided in order to improve the reliability of measurement results. In the present invention, as shown in FIG. 3, two measurement regions are provided on each of an inner circular portion, a middle circular portion, and an outer circular portion of the
25 grinding surface of an annular grindstone with fixed abrasive particles. It is preferable that the two positions are provided so as to have point symmetry with respect to the center of the grindstone with fixed abrasive particles. Upper and lower surface plates are each provided with the above-mentioned measurement

positions. As a result, one grinding apparatus is provided with 12 measurement ranges in total.

[0031]

(3) Any one abrasive particle of a plurality of abrasive particles present in the measurement range is selected, an abrasive particle that is located nearest to that abrasive particle is then selected, and a distance between the centers of these abrasive particles is measured. Then, similar measurements are performed on all the abrasive particles present in the measurement range, and the average value of the obtained measurement values of inter-abrasive-particle distances is used as the inter-abrasive-particle distance for the measurement range. Similar measurements are performed on all of the 12 positions, and the average value of the obtained inter-abrasive-particle distances is used as the "average inter-abrasive-particle distance" for the grindstone with fixed abrasive particles.

[0032]

In the present invention, it is preferable that the above-mentioned fixed abrasive particles are aggregates including diamond abrasive particles. In this case, it is preferable that the average particle diameter (D50) of the diamond abrasive particles is about 1 to 10 μm . It is preferable that the average particle diameter (D50) of the aggregates including diamond abrasive particles is about 15 to 50 μm . If the average particle diameter of the diamond abrasive particles is smaller than the above-mentioned values, shallow cuts are made in the mirror-finished glass substrate, and there is a risk that the grinding of the glass substrate will have difficulty progressing. On the other hand, if the average particle diameter of the diamond abrasive particles is larger than the above-mentioned values, there is a risk that the finished roughness increases, and therefore, the machining allowance load in subsequent steps increases.

[0033]

In the present invention, as described above, a grindstone with fixed

abrasive particles having an average inter-abrasive-particle distance with which a desired processing speed can be obtained is selected based on the correlation, which is determined in advance, between the average inter-abrasive-particle distance and the processing speed obtained when a glass substrate is ground using the grindstone with fixed abrasive particles, and it is preferable that the average inter-abrasive-particle distance is in a range of 80 μm to 200 μm , for example. If the average inter-abrasive-particle distance is too small, not only can the correlation with the processing speed not be obtained, but also the processing speed may decrease due to the excessively small average inter-abrasive-particle distance, and thus the productivity may significantly deteriorate. On the other hand, if the average inter-abrasive-particle distance is too large, the correlation with the processing speed cannot also be obtained, and the processing speed also decreases.

[0034]

It is preferable that on the grinding surface, the density of the above-mentioned fixed abrasive particles contained in the supporting material is in a range of about 10 to 40 particles/ mm^2 .

It is preferable that the content of the fixed abrasive particles in the grindstone with fixed abrasive particles is 5 to 80 vol%. If the content of the fixed abrasive particles is out of the above-mentioned range (i.e., larger or smaller than the range), processing time may increase, and the cost may increase.

[0035]

In the grinding processing in the present invention, it is preferable that the load during the processing is 50 g/cm^2 to 200 g/cm^2 . If the load is smaller than this range, there is a risk that the processing speed will be too slow, and the productivity will deteriorate. If the load is larger than this range, scratches may occur.

It should be noted that when the mirror-finished surface of the glass

substrate is ground with the grindstone with fixed abrasive particles, first, it is preferable to apply a higher load to the glass surface than that in ordinary grinding for the purpose of causing the diamond abrasive particles to cut into the surface of the glass substrate, for example. A high load enables the cuts made by the
5 abrasive particles to be deeper, and thus enables the roughness of the glass surface to be increased (roughened).

[0036]

After the glass surface is roughened in an early stage of such processing, a high load is no longer necessary in the grinding. It is desirable that the load is thus
10 reduced, and grinding is performed under conditions that cause the cuts made by the abrasive particles to be shallower. FIG. 2 is a schematic view for illustrating a state during grinding, and shows a state in which the aggregates 2 including the diamond abrasive particles 4 are cutting into a glass substrate 10 and grinding the glass substrate 10 (image).

[0037]

It is preferable that the load at the start of the above-mentioned processing or in the early stage of the processing is set to be in a range of 130 to 200 g/cm², for example. If the load is smaller than 130 g/cm², the period of time (dead time) during which no grinding is performed is insufficiently reduced, and the processing
20 speed will decrease. On the other hand, if the load is larger than 200 g/cm², cuts made by the abrasive particles will be formed too deeply, and thus a large number of scratches will occur. Therefore, it is necessary to increase the machining allowance in the subsequent processing and the subsequent polishing step, and the processing time will be extended.

Moreover, it is preferable that the load in the stage after the glass surface is roughened is in a range of 50 to 120 g/cm², for example. The surface roughness of the processed surface can be suppressed to a low level by adjusting the grinding conditions.

[0038]

In the present invention, it is preferable that the processing speed during the grinding processing is in a range of about 50 to 160 $\mu\text{m}/\text{minute}$. Therefore, it is desirable that a grindstone with fixed abrasive particles having an average
5 inter-abrasive-particle distance with which such a processing speed can be obtained is selected based on the above-described correlation.

[0039]

In the present invention, the surface of the glass substrate to be subjected to the grinding processing is a mirror-finished surface, and the surface roughness
10 R_a is 0.001 to 0.01 μm , for example.

Moreover, in the present invention, it is preferable that the glass substrate that has undergone the grinding processing is finished such that the surface roughness R_a is in a range of 0.080 to 0.130 μm . Suppressing the finished roughness to a low level in this manner makes it possible to reduce the processing
15 load in subsequent steps.

[0040]

With the present invention, the processing speed can be controlled even when the machining allowance needs to be changed in cases where the thickness of the original material to be subjected to the grinding is changed, and the target
20 thickness after the processing is changed, due to changes in process design, or in a case where the original materials vary in thickness, and therefore, the grinding time can be made constant. Accordingly, when a large number of glass substrates are produced using a large number of grinding apparatuses, the glass substrates can be systematically moved without waste such as loss of time even in
25 a process chain including preprocessing, grinding processing, and postprocessing, thus making it possible to dramatically improve the production efficiency. This is extremely effective in the case where mass production, such as manufacturing of magnetic-disk glass substrates, is a prerequisite.

[0041] In the present invention, it is preferable that the (type of) glass constituting the glass substrate is amorphous aluminosilicate glass. Mirror-polishing the surface of such a glass substrate can yield a smooth mirror-finished surface, and the post-processing strength is favorable. As such aluminosilicate glass, it is possible to use amorphous aluminosilicate glass that has a composition containing SiO_2 in an amount of 58 to 66 wt%; Al_2O_3 in an amount of 13 to 19 wt%; Li_2O in an amount of 3 to 4.5 wt%; Na_2O in an amount of 6 to 13 wt%; K_2O in an amount of 0 to 5 wt%; MgO in an amount of 0 to 3.5%; and CaO in an amount of 0 to 7 wt%, for example.

Glass containing SiO_2 as a main component and Al_2O_3 in an amount of 20 wt% or less is preferable. Furthermore, glass containing SiO_2 as a main component and Al_2O_3 in an amount of 15 wt% or less is more preferable. Specifically, it is possible to use phosphorus oxide-free amorphous aluminosilicate glass that contains 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.

[0042]

As heat resistant glass used in next-generation magnetic disks for thermally assisted magnetic recording, 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 5 mol%; BaO in an amount of 0 to 2 mol%; Li_2O in an amount of 0 to 3 mol%; ZnO in an amount of 0 to 5 mol%; Na_2O and K_2O in a total amount of 3 to 15 mol%; MgO , CaO , SrO and BaO in a total amount of 14 to 35 mol%; and ZrO_2 , TiO_2 , La_2O_3 , Y_2O_3 , Yb_2O_3 , Ta_2O_5 , Nb_2O_5 , and HfO_2 in a total amount of 2 to 9 mol%, and 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

[Al₂O₃/(MgO+CaO)] in a range of 0 to 0.30, for example.

The glass may also contain SiO₂ in an amount of 56 to 75 mol%; Al₂O₃ in an amount of 1 to 9 mol%; alkali metal oxide(s) selected from the group consisting of Li₂O, Na₂O, and K₂O in a total amount of 6 to 15 mol%; alkaline earth metal
5 oxide(s) selected from the group consisting of MgO, CaO, and SrO in a total amount of 10 to 30 mol%; and oxide(s) selected from the group consisting of ZrO₂, TiO₂, Y₂O₃, La₂O₃, Gd₂O₃, Nb₂O₅, and Ta₂O₅ in a total amount of more than 0 mol% and 10 mol% or less.

In the present invention, it is preferable that the Al₂O₃ content in the glass
10 composition is 15 wt% or less. Furthermore, it is more preferable that the Al₂O₃ content is 5 mol% or less.

[0043]

After the above-described grinding processing, mirror-polishing is performed to obtain a high precision flat surface.

15 In the present invention, the roughness of the processed surface can be reduced in the grinding by applying the method using fixed abrasive particles instead of a conventional method using loose abrasive particles, and therefore, the amount of glass to be removed in the subsequent mirror-polishing step is small, the processing load is reduced, and the processing cost can be reduced.

20 [0044]

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

[0045]

In the present invention, the surface of the glass substrate that has undergone the mirror-polishing processing is preferably a mirror-finished surface having an arithmetic mean surface roughness Ra of 0.2 nm or less, and more preferably a mirror surface having an arithmetic mean surface roughness Ra of 0.13 nm or less. It should be noted that arithmetic mean roughness Ra in the present invention denotes roughness that is calculated in accordance with Japanese Industrial Standards (JIS) B 0601.

From a practical viewpoint, the surface roughness (above-mentioned arithmetic mean roughness Ra) in the present invention is preferably the surface roughness of a surface shape obtained by performing a measurement under an atomic force microscope (AFM).

[0046]

In the present invention, chemical strengthening processing may be performed. As a method 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. 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, an alkali metal nitrate such as potassium nitrate or sodium nitrate can be preferably used.

[0047]

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.

[0048]

- 5 A protecting layer and a lubricant layer may be formed on the above-mentioned 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.
- 10 The magnetic disk glass substrate obtained according to the present invention can be used to provide a highly reliable magnetic disk.

Working Examples

[0049]

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

Working Examples

- Magnetic-disk glass substrates of these working examples were
- 20 manufactured through (1) a substrate preparation step, (2) a shape processing step, (3) an edge surface polishing step, (4) main surface grinding processing, (5) a main surface polishing step (first polishing step), (6) a chemical strengthening step, and (7) a main surface polishing step (second polishing step) as described below.

[0050]

- 25 (1) Substrate preparation step

A large glass sheet constituted by aluminosilicate glass having a thickness of 1 mm manufactured with a float method was prepared, and was cut into small pieces having a square shape of 70 mm×70 mm using a diamond cutter. Next,

each of the glass pieces was processed into a disk shape that had an outer diameter of 65 mm and an inner diameter of 20 mm using a diamond cutter. As this aluminosilicate glass, glass for chemical strengthening was used that contained SiO_2 in an amount of 58 to 66%, Al_2O_3 in an amount of 13 to 19%, Li_2O in an amount of 3 to 4.5%, Na_2O in an amount of 6 to 13%, K_2O in an amount of 0 to 5%, MgO in an amount of 0 to 3.5%, and CaO in an amount of 0 to 7%.

[0051]

(2) Shape processing step

Next, a diamond grindstone was used to make a hole in the central portion of the glass substrate, and predetermined chamfering processing was performed on the outer circumferential edge surface and the inner circumferential edge surface.

(3) 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.

[0052]

(4) Main surface grinding processing

Using a double-side grinding apparatus, this main surface grinding processing was performed while the glass substrate held by a carrier was set between the upper and lower surface plates to which diamond pads serving as a grindstone with fixed abrasive particles had been attached. In the double-side grinding apparatus, a glass substrate held by a carrier is tightly placed between the upper and lower surface plates to which diamond pads have been attached, the carrier 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 grinding liquid is supplied between the diamond pads and the glass substrate surfaces to be ground, the upper and lower surface plates are rotated, and thus the glass substrate

revolves while rotating on the surface plates so that both surfaces of the glass substrate are ground simultaneously.

The diamond pads included fixed abrasive particles constituted by aggregates including diamond abrasive particles. The aggregates had an average particle diameter of about 25 μm , and the diamond abrasive particles had an average particle diameter (D50) of about 2.5 μm . A plurality of these diamond pads were prepared. The main surface grinding processing was performed while a lubricant was used. The rotation rate of the surface plates and the load applied to the glass substrate were adjusted as appropriate.

10 [0053]

In this grinding processing, the average inter-abrasive-particle distance of the fixed abrasive particles in each of the above-mentioned diamond pads was determined in advance with the above-described method, and each diamond pad was used to process 10000 glass substrates.

15 Then, the correlation between the inter-abrasive-particle distance (average inter-abrasive-particle distance) in each diamond pad and the processing speed (grinding rate) obtained in a case where a glass substrate was ground using the diamond pad was determined. Table 1 and Table 2 below show the results. In Table 1, the values of the abrasive densities are also shown. In addition, FIG. 4
20 shows a graph illustrating the correlation between the inter-abrasive-particle distance (average inter-abrasive-particle distance) and the processing speed (grinding rate) that is obtained based on Table 1 and Table 2.

It should be noted that the above-mentioned grinding processing speed is a value obtained by dividing the entire ground thickness by the entire processing
25 time.

[0054]

5) Main surface polishing step (first polishing step)

Next, the first polishing step to remove blemishes and distortion remaining

after the above-described grinding was performed using a double-side polishing apparatus having the same configuration as that in the grinding step. Specifically, the first polishing step was performed using a hard polisher (hard urethane foam) as a polisher. As a polishing liquid, pure water in which cerium oxide serving as a polishing agent was dispersed was used, and the load and the polishing time were set as appropriate. The glass substrate that had undergone the above-mentioned first polishing step was then subjected to ultrasonic cleaning and dried.

[0055]

(6) Chemical strengthening step

Next, the glass substrate that had undergone the above-mentioned cleaning was chemically strengthened. In the chemical strengthening step, a chemical strengthening liquid in which potassium nitrate and sodium nitrate were mixed was prepared, and the glass substrate that had undergone the above-mentioned cleaning and drying was chemically strengthened by being immersed in a solution obtained by heating and melting the chemical strengthening solution.

[0056]

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

Next, the second polishing step was performed using the same double-side polishing apparatus as used in the above-mentioned first polishing step, but polishing pads of a soft polisher (suede) (made of polyurethane foam) was used. This second polishing step is mirror-polishing processing to finish the main surfaces of the glass substrate into smooth mirror-finished surfaces with a surface roughness Ra of about 0.2 nm or less, for example, while the flat surfaces obtained in the above-mentioned first polishing step is maintained. As a polishing liquid, pure water in which cerium oxide was dispersed was used, and the load and the polishing time were set as appropriate. The glass substrate that had undergone the above-mentioned second polishing step was then subjected to ultrasonic

cleaning and dried.

[0057]

Moreover, the surface roughnesses of the main surfaces of the glass substrate obtained through the above-mentioned steps were measured under an atomic force microscope (AFM), revealing that a glass substrate with an ultra-smooth surface having an Rmax of 1.53 nm and an Ra of 0.13 nm was obtained. The main surfaces of the glass substrate were mirror-finished surfaces, and when the main surfaces were analyzed using a laser-type surface defect analyzer, no surface defects such as abnormal projections or blemishes were observed. In addition, the resulting glass substrate had an outer diameter of 65 mm, an inner diameter of 20 mm, and a thickness of 0.635 mm.

[0058] [Table 1]

	Inter-abrasive-particle distance (μm)	Abrasive density (particle/ mm^2)	Grinding rate ($\mu\text{m}/\text{min}$)
Table 1	131	18.2	100
	153	10.8	119
	115	16	82

[0059] [Table 2]

	Inter-abrasive-particle distance (μm)	Grinding rate ($\mu\text{m}/\text{min}$)
Table 2	40	32
	49	44
	71	31
	80	54
	200	160
	300	50

15

[0060]

The following points were revealed by the results shown in Table 1 and Table 2 given above.

The processing speed (grinding rate) showed a low correlation with the density of the abrasive particles, but a high correlation with the

20

inter-abrasive-particle distance (average inter-abrasive-particle distance). In particular, the inter-abrasive-particle distance (average inter-abrasive-particle distance) in a range of 80 μm to 200 μm showed a good correlation with the grinding rate (see FIG. 4).

5 Accordingly, by selecting, based on the determined correlation, and using this grindstone with fixed abrasive particles having an inter-abrasive-particle distance with which a desired processing speed can be obtained, it is possible to increase the processing speed and obtain stable grinding performance. Therefore, it is possible to increase the processing speed and perform stable grinding.

10 It should be noted that similar investigations were also performed in the cases where the diamond abrasive particles had an average particle diameter (D50) of 1.5 μm and the aggregates had an average particle diameter (D50) of 15 μm , and the diamond abrasive particles had an average particle diameter (D50) of 9 μm and the aggregates had an average particle diameter (D50) of 50 μm ,
15 revealing that the average inter-abrasive-particle distance in a range of 80 μm to 200 μm showed a good correlation with the grinding rate.

[0061]

Manufacturing of magnetic disk

20 Magnetic disks for perpendicular magnetic recording were manufactured by performing the following film forming steps on the magnetic-disk glass substrates obtained in the above-mentioned working examples.

 Specifically, an adherent layer in the form of a Ti-based alloy thin film, a soft magnetic layer in the form of a CoTaZr alloy thin film, a base layer in the form of a Ru thin film, a perpendicular magnetic recording layer made of a CoCrPt alloy, a
25 protecting layer, and a lubricant layer were formed in sequence on the glass substrate. As the protecting layer, a hydrogenated carbon layer was formed. The lubricant layer was formed with a dipping method using an alcohol-modified perfluoropolyether liquid 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 result,

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

List of Reference Numerals

[0062]

	1	Diamond pad
10	2	Abrasive aggregate (assembled abrasive particles)
	3	Supporting material
	4	Diamond particle
	10	Glass substrate

CLAIMS

1. A method for manufacturing a magnetic-disk glass substrate comprising performing grinding processing for grinding main surfaces of a glass substrate using a lubricant and upper and lower surface plates having a grinding surface respectively provided with a grindstone with fixed abrasive particles while the glass substrate is pressed by the upper and lower surface plates,
wherein the grindstone with fixed abrasive particles includes fixed abrasive particles contained in a supporting material,

a correlation between an average inter-abrasive-particle distance of the fixed abrasive particles on the grinding surface of the grindstone with fixed abrasive particles and a processing speed obtained when the glass substrate is ground using the grindstone with fixed abrasive particles is determined in advance, and a grindstone with fixed abrasive particles having an average inter-abrasive-particle distance with which a desired processing speed can be obtained is selected based on the determined correlation, and the grinding processing is performed using the selected grindstone with fixed abrasive particles.

2. A method for manufacturing a magnetic-disk glass substrate comprising performing grinding processing for grinding main surfaces of a glass substrate using a lubricant and upper and lower surface plates having a grinding surface respectively provided with a grindstone with fixed abrasive particles while the glass substrate is pressed by the upper and lower surface plates,
wherein the grindstone with fixed abrasive particles includes fixed abrasive particles contained in a supporting material, and

the fixed abrasive particles have an average inter-abrasive-particle distance of 80 μm to 200 μm on the grinding surface of the grindstone with fixed abrasive particles.

3. The method for manufacturing a magnetic-disk glass substrate

according to claim 1, wherein the average inter-abrasive-particle distance is 80 μm to 200 μm .

4. The method for manufacturing a magnetic-disk glass substrate according to any of claims 1 to 3, wherein the fixed abrasive particles have an
5 average particle diameter of 15 μm to 50 μm .

5. The method for manufacturing a magnetic-disk glass substrate according to claims 1 to 4, wherein the fixed abrasive particles include diamond abrasive particles.

6. The method for manufacturing a magnetic-disk glass substrate
10 according to claims 1 to 5, wherein the fixed abrasive particles are constituted by abrasive particles or abrasive aggregates consisting of a plurality of abrasive particles held together with a binder.

7. The method for manufacturing a magnetic-disk glass substrate according to claims 1 to 6, wherein the main surface of the glass substrate is a
15 mirror-finished surface at a start of the grinding processing.

8. The method for manufacturing a magnetic-disk glass substrate according to claims 1 to 7, wherein a processing load is 50 g/cm^2 to 200 g/cm^2 .

9. A method for manufacturing a magnetic disk comprising manufacturing a magnetic-disk glass substrate with the method according to any of claims 1 to 8,
20 and forming at least a magnetic recording layer on the manufactured magnetic-disk glass substrate.

10. A method for manufacturing a glass substrate comprising performing grinding processing for grinding main surfaces of a glass substrate using a
25 lubricant and upper and lower surface plates having a grinding surface respectively provided with a grindstone with fixed abrasive particles while the glass substrate is pressed by the upper and lower surface plates,

wherein the glass substrate is a material for a magnetic-disk glass

substrate,

wherein the grindstone with fixed abrasive particles includes fixed abrasive particles contained in a supporting material, and

the fixed abrasive particles have an average inter-abrasive-particle
5 distance of 80 μm to 200 μm on the grinding surface of the grindstone with fixed abrasive particles.

11. The method for manufacturing a glass substrate according to claim 10, wherein the fixed abrasive particles include diamond abrasive particles.

12. A method for manufacturing a magnetic-disk substrate comprising
10 manufacturing a glass substrate with the method according to claim 10 or 11, and performing at least polishing processing to the main surfaces of the manufactured glass substrate.

13. A grindstone with fixed abrasive particles provided with a grinding
surface of each of upper and lower surface plates used for performing grinding
15 processing for grinding main surfaces of a glass substrate while the glass substrate is pressed by the upper and lower surface plates,

wherein the grindstone with fixed abrasive particles includes fixed abrasive particles contained in a supporting material,

wherein the fixed abrasive particles include diamond abrasive particles,
20 and

the fixed abrasive particles have an average inter-abrasive-particle
distance of 80 μm to 200 μm on the grinding surface of the grindstone with fixed
abrasive particles.

14. A grindstone with fixed abrasive particles according to claim 13,
25 wherein the fixed abrasive particles are constituted by abrasive particles or

abrasive aggregates consisting of a plurality of abrasive particles held together with a binder.