

DESCRIPTION

Title of Invention:

GRINDING TOOL, METHOD FOR MANUFACTURING GLASS SUBSTRATE,
METHOD FOR MANUFACTURING MAGNETIC-DISK GLASS SUBSTRATE,
5 AND METHOD FOR MANUFACTURING MAGNETIC DISK

Technical Field

[0001]

The present invention relates to a grinding tool to be applied in
10 manufacturing a magnetic-disk glass substrate to be provided in a magnetic disk
apparatus such as a hard disk drive (HDD), a method for manufacturing a
magnetic-disk glass substrate using the grinding tool, and a method for
manufacturing a magnetic disk.

15 Background Art

[0002]

Magnetic disks are one type of information recording media to be
provided in magnetic disk apparatuses such as hard disk drives (HDDs).
Magnetic disks are configured with a thin film such as a magnetic layer formed
20 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 narrower than with aluminum substrates have been
increasingly used.

25 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 and a lower cost has been increasing, and in order to achieve

this, further improvement in the quality and reduction of the price of magnetic-disk glass substrates is required.

[0003]

As described above, it is essential for a magnetic disk to have a highly
5 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 this
kind of glass substrate, extremely high smoothness on the main surfaces has
10 been realized by adjusting the plate thickness and reducing the flatness with
grinding processing, whereafter polishing processing is furthermore performed
so as to reduce the surface roughness and minute undulations.

[0004]

Incidentally, a method for grinding with fixed abrasive particles has been
15 proposed (e.g., Patent Literature 2 and the like) in which a diamond pad is used
in a grinding step in which loose abrasive particles were conventionally used
(e.g., Patent Literature 1 and the like). A diamond pad is a sheet on which
diamond particles or aggregates (assembled abrasive particles) consisting of
several diamond particles held together with a fixing material such as glass are
20 fixed by using a bonding material such as resin (e.g., acrylic resin).

Alternatively, a diamond pad may be obtained by forming a layer of resin
including diamond on a sheet and thereafter forming grooves in the resin layer
so as to make protruding shapes. It should be noted that although the term
"diamond pad" used here is not necessarily in common usage, "diamond pad"
25 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, 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.

Patent Literature 2 discloses a tool for grinding processing with fixed abrasive particles in which polishing complexes (aggregates) obtained by bonding diamond abrasive particles using a binder are dispersed at a constant proportion in an organic resin.

20

Prior Art Document(s)

Patent Literature(s)

[0006]

Patent Literature 1: JP 2001-6161 A

25 Patent Literature 2: JP 2003-534137 A

Summary of Invention

Problem to be Solved by the Invention

[0007]

As described above, although the method for grinding with fixed abrasive particles using a diamond pad makes it possible to reduce the surface roughness of the processed surface and reduces the load on a subsequent mirror-polishing step, making it possible to reduce the cost of processing a glass substrate, the inventor found the following problems as a result of studies.

[0008]

If a glass substrate is ground using a tool for grinding processing with fixed abrasive particles such as that disclosed in Patent Document 2 above, an aggregate density suitable for the item to be processed needs to be selected, and the processing pressure needs to be adjusted so that the pressure applied to the tip portions (blade ends) of the diamond particles is always controlled. In particular, if the processing is to be performed quickly, it is advantageous to select a grinding tool with a low aggregate density. In this case, since the interval between the aggregates is large, the processing speed increases, but the tool also wears quickly. Also, if the aggregate density is low, the distance between the dispersed aggregates tends to become non-uniform, and uneven wearing is likely to occur. If the glass substrate is mass-produced using this kind of conventional grinding tool, the processing speed is high in the initial stage, but fall-off of the grinding abrasive particles, uneven wear, clogging, and the like repeatedly occur, which causes undulating components to be formed on the tool surface, and thereby a decrease in processing speed and a decrease in the post-processing quality occur at a relatively early stage (upon elapse of several batches from the start of processing). The decrease in the quality of the flatness is particularly significant. It is possible to recover the processing speed if it decreases due to a correction task for removing the undulating components that appeared in the tool surface, but since this kind of correction task needs to be performed frequently, the burden on productivity is large.

In short, with the conventional technique, it is difficult to achieve both the processing speed and the processing quality (particularly the flatness of the substrate), and a favorable processing quality cannot be obtained stably over a long period of time at a stable processing speed.

5 [0009]

The present invention has been made in order to resolve such conventional problems, and it is an object thereof to provide a grinding tool to be applied in grinding processing for a glass substrate, according to which both a processing speed and a processing quality (particularly the flatness of the

10 substrate) are achieved in grinding processing with fixed abrasive particles, and according to which a favorable processing quality is obtained stably over a long period of time at a stable processing speed, and to provide a method for manufacturing a magnetic-disk glass substrate, which includes grinding processing using the grinding tool, and according to which a high-quality glass

15 substrate can be manufactured, and a method for manufacturing a magnetic disk using the thus-obtained glass substrate.

Means to Solve the Problem

[0010]

20 The inventor achieved the present invention as a result of finding a solution by which it is possible to increase the processing speed and perform stable grinding processing.

That is, in order to solve the foregoing problems, the present invention has the following aspects.

25 (Aspect 1)

A method for manufacturing a magnetic-disk glass substrate including grinding processing for grinding a main surface of a glass substrate, in which in the grinding processing, a glass substrate main surface is ground using a

grinding tool that includes grinding abrasive particles, a bonding material for bonding the grinding abrasive particles, and dispersion particles that are harder than the bonding material and softer than the grinding abrasive particles, the grinding abrasive particles and the dispersion particles being dispersed and
5 bonded in the bonding material.

[0011]

(Aspect 2)

The method for manufacturing a magnetic-disk glass substrate according to aspect 1, in which the bonding material is a resin material.

10 (Aspect 3)

The method for manufacturing the magnetic-disk glass substrate according to aspect 1 or 2, in which the grinding abrasive particles are assembled abrasive particles in which a plurality of grinding abrasive particles are bonded with a fixing material.

15 [0012]

(Aspect 4)

The method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 3, in which the grinding abrasive particles include diamond abrasive particles.

20 (Aspect 5)

The method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 4, in which the dispersion particles are made of alumina or zirconia.

[0013]

25 (Aspect 6)

The method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 4, in which the dispersion particles are made of glass that is softer than glass to be ground.

(Aspect 7)

The method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 4, in which the dispersion particles are aggregates in which a plurality of dispersion particles are bonded with glass that
5 is softer than glass to be ground.

[0014]

(Aspect 8)

The method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 7, in which a proportion of the dispersion
10 particles with respect to the grinding abrasive particles in the bonding material is such that 0.1 to 5 dispersion particles exist per grinding abrasive particle.

(Aspect 9)

A method for manufacturing a magnetic disk, in which at least a magnetic recording layer is formed on a magnetic-disk glass substrate
15 manufactured using the method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 8.

[0015]

(Aspect 10)

A grinding tool for grinding a surface of a glass substrate for an
20 electronic device, including:

grinding abrasive particles; a bonding material for bonding the grinding abrasive particles; and dispersion particles that are harder than the bonding material and softer than the grinding abrasive particles, wherein the grinding abrasive particles and the dispersion particles are dispersed and bonded in the
25 bonding material.

Brief Description of Drawings

[0016]

With the present invention, the conventional problems can be solved using the above-described configuration, and it is possible to provide a grinding tool to be applied in grinding processing for a glass substrate, according to which both a processing speed and a processing quality (particularly a flatness of a substrate) are achieved in grinding processing with fixed particles, and according to which a favorable processing quality is obtained stably over a long period of time at a stable processing speed. Also, it is possible to include grinding processing using this grinding tool and to manufacture a high-quality glass substrate at a low cost. Furthermore, a magnetic disk with high reliability can be obtained using the thus-obtained glass substrate.

Brief Description of Drawings

[0017]

FIG. 1 is a schematic cross-sectional view showing a configuration of a conventional diamond pad.

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

Description of Embodiments

[0018]

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

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

In the method for manufacturing a magnetic-disk glass substrate according to the present invention, a glass substrate is obtained by cutting a sheet of glass manufactured using a float method or a downdraw method into a predetermined size. Alternatively, sheet-like sheet glass produced from molten

glass by pressing may also be used. The present invention is preferable in the case of using a glass substrate with mirror-finished main surfaces at a time of starting grinding processing.

[0019]

5 Next, this glass substrate is subjected to grinding processing for improving the dimensional accuracy and shape accuracy.

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

[0020]

 The present invention relates to an improvement in the grinding
15 processing. The grinding processing in the present invention is grinding that uses grinding abrasive particles (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 grinding tools are attached, for
20 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 processed surfaces and
25 promote processing.

[0021]

 The grinding tool (fixed abrasive particle grindstone) used in the grinding processing is, for example, a diamond pad, an overall configuration of which is

shown in FIG. 1. Assembled abrasive particles 3 in which several diamond particles 5 (see FIG. 2) are held together with a fixing material such as glass are fixed by using a bonding material such as a resin (e.g., acrylic resin) to obtain pellets 4, which are attached to a sheet 2, thus forming the diamond pad 1

5 shown in FIG. 1. 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 layer of resin containing diamond particles on a sheet and thereafter forming grooves in the resin layer to make protruding shapes may be used.

10 [0022]

It should be noted that “fixed abrasive particles” or simply “abrasive particles” mentioned in the present embodiment refer to grinding abrasive particles such as the above-described diamond particles unless particularly stated otherwise, and “average particle diameter of the abrasive particles” refers to the average particle diameter of the above-described grinding abrasive particles.

[0023]

As described above as well, the inventor found that with the above-described conventional technique, it is difficult to achieve both the processing speed and the processing quality (particularly the flatness of the substrate), and a favorable processing quality cannot be obtained stably over a long period of time at a stable processing speed.

In view of this, the inventor searched for a solution according to which the processing speed could be increased and stable grinding processing could be performed, and found as a result that the above-described problems could be solved by applying a grinding tool in which grinding abrasive particles and dispersion particles softer than the grinding abrasive particles are both used and the grinding abrasive particles and the dispersion particles are dispersed and

bonded in a bonding material.

[0024]

With the grinding tool of the present invention, when the glass substrate is interposed between the upper and lower surface plates, the forces applied to the grinding abrasive particles by the surface plates is dispersed due to the
5 the grinding abrasive particles by the surface plates is dispersed due to the existence of the above-described dispersion particles. In other words, the processing speed can be increased by reducing the grinding abrasive particle density and increasing the interval between the grinding abrasive particles, and since dispersion particles exist between the grinding abrasive particles even if
10 the grinding abrasive particle interval is large, the forces applied by the surface plates at the time of processing can be dispersed, whereby it is possible to suppress wearing of the tool. Also, although the distances between the dispersion particles tend to be non-uniform when the grinding particle density is low, in the present invention, as described above, dispersion particles are
15 dispersed in addition to the grinding abrasive particles, as a result of which the grinding abrasive particles are dispersed at uniform distances, and uneven wearing is less likely to occur.

[0025]

Accordingly, even if glass substrates are mass-produced using this kind of grinding tool of the present invention, it is possible to suppress a case in which
20 undulating components are formed on the tool surface when processing as with the conventional technique is performed continuously. As a result, it is possible to achieve both the processing speed and the processing quality (particularly the flatness of the substrate), and a favorable processing quality is obtained stably
25 over a long period of time at a stable processing speed.

[0026]

That is, the grinding tool to be applied to the grinding processing in the present invention is a grinding tool that grinds a glass substrate surface and

includes grinding abrasive particles, a bonding material that bonds the grinding abrasive particles, and dispersion particles that are harder than the bonding material and softer than the grinding abrasive particles, the grinding abrasive particles and dispersion particles being dispersed and bonded in the bonding material.

Also, with the present invention, in grinding processing for grinding a glass substrate, the main surfaces of the glass substrate are ground using the grinding tool.

[0027]

The grinding abrasive particles may simply be abrasive particles, but are preferably assembled abrasive particles in which multiple grinding abrasive particles are bonded with a fixing material. A single abrasive particle has a small surface area and therefore has low resin strength for holding on and is likely to fall off.

In the present invention, the grinding abrasive particles are preferably diamond abrasive particles. In this case, the average particle diameter of the diamond abrasive particles is preferably within a range of about 1.5 to 10 μm .

If the average particle diameter of the diamond abrasive particles falls below the above-described range, the mirror-finished glass substrate is not penetrated deeply, and cutting into the glass substrate is less likely to advance. On the other hand, if the average particle diameter of the diamond abrasive particles exceeds the above-described range, the finishing roughness increases, and therefore there is a risk that the machining allowance load in a subsequent step will be large.

Also, in the case of using the diamond assembled abrasive particles, the particle diameters of the assembled abrasive particles are preferably such that a cumulative average particle diameter is about 30 to 50 μm .

Also, a glass material, for example, is preferable as the fixing material for

fixing the abrasive particles together.

[0028]

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

[0029]

Examples of bonding materials for bonding the grinding abrasive particles include metal, glass, and a resin material, but a resin material is
15 particularly preferable from the viewpoint of having a suitable cushioning property so as not to excessively damage the glass. Examples of resin materials include acrylate, epoxy, polycarbonate, and polyester.

[0030]

In the present invention, the above-described dispersion particles
20 dispersed in the bonding material along with the grinding abrasive particles are particles that are harder than the bonding material and softer than the grinding abrasive particles. The forces applied to the grinding abrasive particles by the surface plates when the glass substrate is interposed between the upper and lower surface plates during processing can be dispersed due to the presence of
25 the dispersion particles. The hardness of the dispersion particles also depends on the materials of the bonding material and the grinding abrasive particles, but since the grinding abrasive particles have an approximate Mohs' hardness of about 6.5 to 9.5, it is sufficient to have a hardness that is softer than that. Also,

the glass used in the particles preferably has a Mohs' hardness that is lower compared to that of the abrasive particles.

[0031]

As long as the dispersion particles fulfill the above-described conditions
5 relating to hardness, there is no particular limitation on the material thereof, but from the viewpoint of the Mohs' hardness, they are preferably made of glass, alumina, or zirconia. Also, a mixture of particles of different materials may be used. Since these materials are appropriately softer than diamond, they are worn before the diamond particles. Therefore, the processing of the diamond is
10 not hindered. The range of the average particle diameter of alumina or zirconia particles is preferably similar to that of the average particle diameter of the diamond particles.

[0032]

The dispersion particles may simply be particles, or they may be
15 aggregates in which multiple dispersion particles are bonded using a glass fixing material, as with vitrified bonding, for example. The materials of the multiple dispersion particles in this case may be the same or different. Also, the glass in this case is preferably glass that is softer than the glass substrate to be ground.

In the case of simply using particles, the size of the dispersion particles
20 is preferably the same as in the case of using the aggregates. This makes it easier to disperse both of them uniformly.

Also, regarding the ratio between the size of the grinding abrasive
particles (the size of the assembled abrasive particles in the case of using the assembled abrasive particles) and the size of the dispersion particles, they are
25 preferably approximately equal, and it is particularly desirable that both are the same size. The size ratio of the grinding abrasive particles and the dispersion particles is the ratio of the average particle diameter of the dispersion particles with respect to the average particle diameter of the grinding abrasive particles

((average particle diameter of dispersion particles)/(average particle diameter of grinding abrasive particles)) and preferably falls within the range of 0.8 to 1.2.

This makes it easier to disperse both of them uniformly..

Also, in the case of using a fixing material for the grinding abrasive
 5 particles and a fixing agent for the dispersion particles, both bonding materials are preferably the same material. This makes it easier to disperse both of them uniformly.

[0033]

Also, the dispersion particles may be particles made of only glass that is
 10 softer than the glass to be ground.

In the case of using dispersion particles made of only this glass, the size of the dispersion particles, the size ratio with respect to the grinding abrasive particles, and the like are similar to those in the case of using the dispersion particles made of alumina or the like.

15 [0034]

The grinding tool of the present invention is such that the grinding
 abrasive particles and the dispersion particles are dispersed and bonded in the bonding material, but specifically, for example, use of diamond grinding abrasive particles and non-diamond dispersion particles such as alumina, use of diamond
 20 grinding abrasive particles and dispersion particles made of glass, use of diamond grinding abrasive particles, non-diamond dispersion particles such as alumina, and dispersion particles made of glass, and the like are examples of embodiments.

In the present invention, an embodiment of using the diamond grinding
 25 abrasive particles and the dispersion particles made of glass is particularly preferable. With this embodiment, the dispersion effect that prevents the occurrence of undulating components is optimal.

[0035]

In the present invention, there is no particular limitation on the proportion of the grinding abrasive particles and the dispersion particles in the bonding material, but it is preferable to use the following dispersion proportion from the viewpoint of the effect of the present invention being sufficiently exhibited.

5 In the case of using diamond grinding abrasive particles and non-diamond dispersion particles such as alumina, it is preferable that 0.1 to 3 dispersion particles exist per grinding abrasive particle.

 In the case of using diamond grinding abrasive particles and dispersion particles made of glass, it is preferable that 0.1 to 5 dispersion particles exist per
10 grinding abrasive particle.

 Also, in the case of using diamond grinding abrasive particles, non-diamond dispersion particles such as alumina, and dispersion particles made of glass, it is preferable that 0.1 to 5 dispersion particles in total exist per grinding abrasive particle.

15 Also, the total density on the grinding surface of the fixed abrasive particles (each assembled abrasive particle or aggregate is counted individually) dispersed in bonding material such as resin is preferably within a range of 10 to 40 (pieces/mm²). Also, the content of fixed abrasive particles in the grinding tool is preferably 5 to 80 vol%. If the content of the fixed abrasive particles is
20 outside of the above-described range (either exceeding or falling below it), an increase in the processing time is incurred in some cases, resulting in a higher cost.

 In the present invention, the abrasive particles of the material that is softer than the diamond abrasive particles and the aggregates thereof are
25 dispersed along with the diamond assembled abrasive particles, whereby the distance between the diamond assembled abrasive particles can be extended uniformly. Also, an excessive concentration of force on the diamond assembled abrasive particles can be prevented. Accordingly, the processing

can be stabilized at high processing speeds as well, and favorable flatness can be maintained.

[0036]

In the grinding processing in the present invention, the load during
5 processing is preferably 15 g to 200 g/cm², in surface pressure.

It should be noted that if a mirror-finished glass substrate surface is ground using a diamond pad, for example, first, a load burden that is higher than that during normal grinding processing is preferably applied to the glass surface in order to cause the diamond abrasive particles to cut into the glass substrate
10 surface. Because a high load causes the penetration depth of the abrasive particles to increase accordingly, it is possible to increase (roughen) the roughness of the glass surface.

After the glass surface is roughened in an initial stage of this kind of processing, no high load is needed in the grinding processing, and rather, it is
15 desirable to perform processing under conditions such that the load is reduced and the penetration depth of the abrasive particles is shallower. FIG. 2 is a schematic view illustrating a state during grinding processing and shows a state of performing grinding with the diamond abrasive particles 3 cutting into the glass substrate 10 (conceptual drawing).

20 [0037]

In the present invention, the glass substrate after the end of the grinding processing is preferably finished such that the surface roughness Ra is in a range of 0.02 to 3.0 μm. By suppressing the finishing roughness to a low level in this manner, the processing load on a subsequent step can be reduced.

25 [0038]

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 preferable to use glass that contains SiO_2 as a main component, and Al_2O_3 in an amount of 20 wt% or less, for example.

Furthermore, it is more preferable to use glass that contains SiO_2 as a main
 5 component and Al_2O_3 in an amount of 15 wt% or less. 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
 10 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.

[0039]

Also, as heat resistant glass to be used in a next-generation magnetic
 15 disk for heat-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 ,
 20 Y_2O_3 , Yb_2O_3 , Ta_2O_5 , Nb_2O_5 , and HfO_2 in a total amount of 2 to 9 mol%, and has a molar ratio $[(\text{MgO}+\text{CaO})/(\text{MgO}+\text{CaO}+\text{SrO}+\text{BaO})]$ in a range of 0.85 to 1, and a molar ratio $[\text{Al}_2\text{O}_3/(\text{MgO}+\text{CaO})]$ in a range of 0 to 0.30, for example.

Also, it is possible to use glass that contains SiO_2 in an amount of 56 to
 75 mol%, Al_2O_3 in an amount of 1 to 9 mol%, an alkali metal oxide selected from
 25 a group consisting of Li_2O , Na_2O , and K_2O in a total amount of 6 to 15 mol%, an alkaline earth metal oxide selected from the group consisting of MgO , CaO , and SrO in a total amount of 10 to 30 mol%, an oxide selected from ZrO_2 , TiO_2 , Y_2O_3 , La_2O_3 , Gd_2O_3 , Nb_2O_5 , and Ta_2O_5 in a total amount of more than 0% and 10

mol% or less.

In the present invention, the content of Al_2O_3 in the glass composition is preferably 15 wt% or less. Furthermore, the content of Al_2O_3 is more preferably 5 mol% or less.

5 [0040]

After the above-described grinding processing ends, mirror-polishing for obtaining a high-precision flat surface is performed. In the present invention, since stable processing can be performed in the grinding processing using the fixed abrasive particles, the removal amount in the subsequent mirror-polishing
10 is small, the processing load is reduced, and it is possible to reduce the processing cost.

[0041]

The method for performing mirror-polishing on the glass substrate is preferably performed using polishing pads of a polisher such as polyurethane
15 while a slurry (polishing liquid) containing a polishing material that is a metal oxide such as cerium oxide or colloidal silica is supplied. A highly-smooth glass substrate can be obtained by performing polishing using a cerium oxide-based polishing material, for example (first polishing processing), after which finishing polishing (mirror-polishing) is furthermore performed using colloidal silica
20 abrasive particles (second polishing processing).

[0042]

In the present invention, the surface of the glass substrate subjected to the mirror-polishing processing is preferably a mirror-finished surface with an arithmetic average surface roughness R_a of 0.2 nm or less, and more preferably
25 0.1 nm or less. It should be noted that arithmetic average surface roughness R_a as used in the present invention denotes a roughness calculated in accordance with the Japanese Industrial Standards (JIS) B 0601.

From a practical viewpoint, the surface roughness (the above-mentioned

arithmetic average surface roughness) in the present invention is preferably the surface roughness of a surface shape obtained by measuring using an atomic force microscope (AFM).

[0043]

5 In the present invention, chemical strengthening processing can 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. The chemical strengthening processing is processing in which a
10 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, whereby the alkali metal element having a large ionic radius permeates through the surface layer of the
15 glass substrate, and compressive stress is generated on the surface of the glass substrate. A glass substrate subjected to the chemical strengthening processing has excellent impact resistance, and therefore, it is particularly preferable to mount the glass substrate on an HDD for mobile use, for example. As the chemical strengthening salt, an alkali metal nitrate such as potassium
20 nitrate or sodium nitrate can be preferably used.

[0044] 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
25 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.

[0045]

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

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

10

Working Examples

[0046]

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

Working Example 1

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

[0047]

(1) Substrate preparation

Large sheet glass made of aluminosilicate glass with a thickness of 1
25 mm was manufactured using a float method and cut into small 70 mm x 70 mm square pieces using a diamond cutter. Next, the diamond cutter was used to process the small pieces into disk shapes with an outer diameter of 65 mm and an inner diameter of 20 mm. As this aluminosilicate glass, glass capable of

being chemical strengthened and containing SiO_2 in an amount of 62 to 75 wt%, ZrO_2 in an amount of 5.5 to 15 wt%, Al_2O_3 in an amount of 5 to 15 wt%, Li_2O in an amount of 4 to 10 wt%, and Na_2O in an amount of 4 to 12 wt% was used.

The surface of the obtained substrate was a mirror-finished surface with
 5 a surface roughness R_a of 5 nm or less.

[0048]

(2) Shape processing

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

[0049] (3) Edge surface polishing processing

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

[0050] (4) Main surface grinding processing

A glass substrate held by a carrier was set between upper and lower surface plates to which diamond pads were attached so as to perform the main surface grinding processing using a double-side grinding apparatus. In the
 20 present working example, as the diamond pads, diamond pads were used which contained assembled abrasive particles in which multiple diamond abrasive particles were held together with glass, aggregates in which multiple alumina particles are fixed with glass, and resin for bonding the multiple assembled abrasive particles and the aggregates, the average particle diameter of the
 25 diamond abrasive particles being $4.0\text{ }\mu\text{m}$, the average particle diameter of the diamond assembled abrasive particles being $40\text{ }\mu\text{m}$, the average particle diameter of the alumina particles being $4.0\text{ }\mu\text{m}$, the average particle diameter of the alumina aggregates being $40\text{ }\mu\text{m}$, the maximum particle diameter being 45

μm, and the diamond assembled abrasive particles and alumina aggregates
 being dispersed in the resin such that the ratio of the diamond assembled
 abrasive particles and the alumina aggregates was 1:0.5. The glass holding
 together the above-described abrasive particles and the like had a lower
 5 hardness than the glass to be processed. Also, the total density of the fixed
 abrasive particles on the grinding surface was 20 (pieces/mm²). Processing
 was performed while a lubricating liquid was used. Also, the rotation rate of the
 surface plates and the load on the glass substrates was adjusted as appropriate.
 [0051]

10 (5) Main surface polishing (first polishing)

Next, first polishing for removing blemishes and distortion remaining
 after the above-described grinding processing was performed using a
 double-side polishing apparatus. In the double-side polishing apparatus, a
 glass substrate held by a carrier is tightly placed between the upper and lower
 15 polishing surface plates to which polishing 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 polishing liquid
 is supplied between the polishing pads and the glass substrate surfaces to be
 polished, the upper and lower surface plates are rotated, and thus the glass
 20 substrate revolves while rotating on the surface plates so that both surfaces of
 the glass substrate are polished simultaneously. Specifically, the first polishing
 was performed using a hard polisher (hard urethane foam) as a polisher. Pure
 water in which cerium oxide was dispersed as an abrasive was used as the
 polishing liquid, and the load and polishing time were set as appropriate. The
 25 glass substrate that was subjected to the above-described first polishing step
 was immersed in cleaning tanks of a neutral detergent, pure water, IPA
 (isopropyl alcohol), and IPA (vapor drying) in sequence, was subjected to
 ultrasound cleaning, and dried.

[0052]

(6) Chemical strengthening

Next, chemical strengthening was performed on the glass substrate that was subjected to the above-described cleaning. Chemical strengthening
5 processing was performed by preparing a chemical strengthening liquid obtained by mixing potassium nitrate and sodium nitrate, heating this chemical strengthening solution to 380°C, and immersing the cleaned and dried glass substrate therein for about 4 hours.

[0053]

10 (7) Main surface polishing (second polishing)

Next, second polishing was performed using the same double-side polishing apparatus as used in the above-mentioned first polishing, but polishing pads (made of polyurethane foam) of a soft polisher (suede) were used instead as the polisher. This second polishing is mirror-polishing processing to finish
15 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 maintaining the flat surfaces obtained in the first polishing described above. Pure water in which colloidal silica was dispersed was used as the polishing liquid, and the load and polishing time were set as appropriate. The glass
20 substrate that had been subjected to the above-described second polishing step was immersed in cleaning tanks of a neutral detergent, pure water, IPA, and IPA (vapor drying) in sequence, was subjected to ultrasound cleaning, and dried.

[0054]

A glass substrate was obtained which had an ultra-smooth surface in
25 which $R_{\max}=1.53$ nm and $R_a=0.13$ nm, which were obtained by measuring the surface roughness of the main surfaces of the glass substrate obtained through the above-described steps using an atomic force microscope (AFM).

[0055]

Working Example 2

A magnetic-disk glass substrate was produced by performing grinding processing in a manner similar to that of Working Example 1, except that in the main surface grinding processing of Working Example 1, diamond pads were
5 used which included assembled abrasive particles in which multiple diamond abrasive particles were held together with glass, multiple dispersion particles made of glass, and resin for bonding the multiple assembled abrasive particles and dispersion particles, the average particle diameter of the diamond abrasive particles being about 4.0 μm , the average particle diameter of the diamond
10 assembled abrasive particles being 40 μm , the average particle diameter of the glass dispersion particles being 4.0 μm , the maximum particle diameter of the glass aggregates being 45 μm , and the diamond assembled abrasive particles and the glass aggregates being dispersed in the resin such that the ratio of the diamond assembled abrasive particles and glass aggregates was 1:0.5.
15 [0056]

Working Example 3

A magnetic-disk glass substrate was produced by performing grinding processing in a manner similar to that of Working Example 1, except that in the main surface grinding processing of Working Example 1, diamond pads were
20 used which contained assembled abrasive particles in which multiple diamond abrasive particles were held together with glass, aggregates in which multiple alumina particles were fixed with glass, multiple dispersion particle aggregates made of glass, and resin for bonding the multiple assembled abrasive particles, alumina particle aggregates, and glass dispersion particle aggregates, the
25 average particle diameter of the diamond abrasive particles being about 4.0 μm , the average particle diameter of the alumina particles being about 1 to 4.0 μm , the average particle diameter of the glass particles being about 1 to 4.0 μm , the maximum particle diameter of the alumina aggregates and the glass aggregates

being 45 μm , and the diamond assembled abrasive particles, alumina aggregates, and glass aggregates being dispersed in the resin such that the ratio of the diamond assembled abrasive particles, alumina aggregates, and glass aggregates was 1:0.5:0.5.

5 [0057]

Comparative Example 1

A magnetic-disk glass substrate was produced by performing grinding processing in a manner similar to that of Working Example 1, except that in the main surface grinding processing of Working Example 1, a conventional
10 diamond pad obtained by dispersing, in resin, assembled abrasive particles in which multiple diamond abrasive particles were held together with glass (the average particle diameter of the diamond abrasive particles was about 4.0 μm), was used.

Comparative Example 2

15 A magnetic-disk glass substrate was produced by performing grinding processing in a manner similar to that of Comparative Example 1, except that a diamond pad was used in which the total density of the fixed abrasive particles (in this example, only the diamond aggregate abrasive particles) on the grinding surface was 30 (pieces/ mm^2).

20 [0058]

In the above-described working examples and comparative examples, the main surface grinding processing was performed continuously for a total of 100 batches, with 100 glass substrates per batch.

In the above-described working examples and comparative examples, a
25 flatness tester was used on the glass substrates resulting from the grinding processing so as to measure the flatness thereof, those meeting a predetermined standard (3 μm or less) were considered acceptable, and the incidence rate of glass substrates that did not meet the standard (flatness defect

rate) was calculated. The results are shown in Table 1. The processing speeds during the grinding processing (processing speed ratios with respect to Comparative Example 1) are also shown in Table 1.

[0059]

5 [Table 1]

Table 1	Configuration of grinding tool	Density of all fixed abrasive particles on grinding surface (pieces/mm ²)	Flatness defect rate	Processing speed ratio
Working Example 1	Uses diamond assembled abrasive particles and alumina particle aggregates	20	0.03%	1.3
Working Example 2	Uses diamond assembled abrasive particles and glass dispersion particles	20	0%	1.1
Working Example 3	Uses diamond assembled abrasive particles, alumina particle aggregates, and glass dispersion particle aggregates	20	0.02%	1.2
Comparative Example 1	Only diamond assembled abrasive particles	20	0.5%	1
Comparative Example 2	Only diamond assembled abrasive particles	30	0.1%	0.9

[0060]

The following can be understood from the results shown in Table 1 above.

1. With Comparative Example 1, in which a grinding tool (diamond pad) including only the conventional diamond assembled abrasive particles was used, the processing speed and processing quality drops and stable grinding processing cannot be performed when 100 batches are processed continuously.

In contrast, in Working Examples 1 to 3, in which a grinding tool obtained

by dispersing alumina particle aggregates, glass dispersion particles, or both alumina particle aggregates and glass dispersion particles together with the diamond assembled abrasive particles was used, both the processing speed and processing quality (particularly the flatness of the substrate) are achieved, and favorable processing quality is obtained stably over a long period of time at a stable processing speed. In particular, with Working Example 2, in which both the diamond assembled abrasive particles and the glass dispersion particles were used, the flatness defect rate was 0%.

Also, by comparing Comparative Examples 1 and 2, it can be understood that if the grinding surface density of the fixed abrasive particles on the conventional diamond pad is reduced, the processing speed increases, but the flatness defect rate worsens. This indicates that stable processing cannot be performed by simply reducing the fixed abrasive particle density.

[0061]

Manufacturing of magnetic disk

Magnetic disks for perpendicular magnetic recording were obtained by performing the following film forming steps on the magnetic-disk glass substrates obtained in Working Example 1 described above.

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 in the form of a CoCrPt alloy, a protecting layer, and a lubricant layer were formed in sequence on the glass substrate. A hydrogenated carbon layer was formed as the protecting layer. The lubricant layer was formed by 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, there was no particular trouble, and good results were obtained.

List of Reference Numerals

5	[0062]	
	1	Diamond pad
	2	Sheet
	3	Assembled abrasive particle
	4	Pellet
10	5	Diamond particle
	10	Glass substrate

CLAIMS

1. A grinding tool for grinding a surface of a glass substrate for an electronic device, comprising:
 - 5 grinding abrasive particles; a bonding material for bonding the grinding abrasive particles; and dispersion particles for dispersing a grinding pressure applied to the grinding abrasive particles, the dispersion particles being harder than the bonding material and softer than the grinding abrasive particles, wherein the grinding abrasive particles and the dispersion particles are
 - 10 dispersed and bonded in the bonding material;
wherein the total density of the grinding abrasive particles and the dispersion particles is within a range of 10 to 40 pieces/mm² on a grinding surface of the grinding tool.
2. The grinding tool according to claim 1, wherein the bonding material
- 15 is a resin material.
3. The grinding tool according to claim 1 or 2, wherein the grinding abrasive particles are assembled abrasive particles in which a plurality of grinding abrasive particles are bonded with a fixing material.
4. The grinding tool according to any of claims 1 to 3, wherein the
- 20 grinding abrasive particles include diamond abrasive particles.
5. The grinding tool according to any of claims 1 to 4, wherein the dispersion particles are made of alumina, zirconia, or glass.
6. The grinding tool according to any of claims 1 to 5, wherein the dispersion particles are aggregates in which a plurality of dispersion particles are
- 25 bonded with glass.
7. The grinding tool according to any of claims 1 to 6, wherein a proportion of the number of the dispersion particles with respect to the number of the grinding abrasive particles in the bonding material is such that 0.1 to 5

dispersion particles exist per grinding abrasive particle.

8. The grinding tool according to any of claims 1 to 7, wherein the grinding abrasive particles are assembled abrasive particles in which a plurality of grinding abrasive particles are bonded with a fixing material and the
- 5 assembled abrasive particles have an average particle diameter of 30 to 50 μm .

9. The grinding tool according to any of claims 1 to 8, wherein the ratio of the average particle diameter of the dispersion particles with respect to the average particle diameter of the grinding abrasive particles falls within a range of 0.8 to 1.2.

- 10 10. A method for manufacturing a glass substrate, comprising grinding processing for grinding a main surface of a glass substrate for an electronic device by using the grinding tool according any of claims 1 to 9.

11. The method for manufacturing a glass substrate according to claim 10, wherein the glass substrate is a material for a magnetic-disk glass substrate.

- 15 12. A method for manufacturing a magnetic-disk glass substrate, wherein at least polishing processing is carried out on a main surface of a glass substrate manufactured by the method according to claim 11.

13. A method for manufacturing a magnetic disk, wherein at least a magnetic recording layer is formed on a magnetic-disk glass substrate
- 20 manufactured using the method for manufacturing a magnetic-disk glass substrate according to claim 12.