

DESCRIPTION

Title of Invention:

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

5

Technical Field

[0001]

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

Background Art

[0002]

Magnetic disks are one type of information recording media to be
15 provided in magnetic disk 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
20 magnetic disk can be made narrower than with aluminum substrates have been
increasingly used. The glass substrate surface is precisely polished such that
the flying height of the magnetic head can be lowered as much as possible to
achieve a high recording density. In recent years, the demand for HDDs with a
larger storage capacity and a lower cost has been increasing, and in order to
25 achieve this, further improvement in the quality and reduction of the cost of
magnetic-disk glass substrates is 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 this

5 kind of glass substrate, extremely high smoothness on the main surfaces has been realized by adjusting the plate thickness and reducing the flatness with grinding processing, whereafter a polishing step is furthermore performed so as to reduce the surface roughness and minute undulations.

[0004]

10 Incidentally, a method for grinding by means of fixed abrasive particles has been proposed (e.g., Patent Literature 2, 3, 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)

15 consisting of several diamond particles held together with a fixing material such as glass are fixed using a supporting material such as resin (e.g., acrylic resin or the like). Alternatively, a diamond pad may be obtained by forming a layer of resin containing 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

20 term "diamond pad" used here is not necessarily in common usage, but in the present embodiment, "diamond pad" will be used herein for the sake of convenience.

[0005]

25 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.

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: WO 2012/090378

Summary of Invention

Problem to be Solved by the Invention

[0007]

As described above, although the grinding method 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.

In the case of performing grinding processing using fixed abrasive particles such as those disclosed in Patent Literature 2 and the like above, the incidence rate of post-processing flatness defects increases. The inventor
5 studied the cause of this and found that grinding unevenness, or in other words, a partial grinding defect (a state in which only a portion of the surface of a glass substrate is ground and the rest is not ground), had occurred. In particular, it was found that the above-described defect occurred significantly in the case of processing a mirror-finished glass substrate produced using a float method or
10 the like, and in the case where the grinding abrasive particle diameter is smaller.
[0008]

As a result of studies carried out by the inventor, it was also found that the following problems were furthermore present.

Conventionally, in the case of performing grinding processing on a
15 surface of a glass substrate by interposing the glass substrate between upper and lower surface plates with grinding surfaces provided with fixed abrasive particles containing diamond particles or the like (diamond pads), the upper surface plate and the lower surface plate have different execution pressures, and it is known that the upper surface plate normally has a larger execution
20 pressure and a higher processing rate than the lower surface plate.

Patent Literature 4 above discloses that grinding processing is performed with a surface of the glass substrate with large undulations arranged on the upper surface plate side and a surface of the glass substrate with small undulations arranged on the lower surface plate side. Glass substrates
25 produced using a float method or the like have different surface undulations on the front and rear surfaces thereof, and if glass substrates are arranged between the upper and lower surface plates of the grinding apparatus randomly regardless of the front or rear surfaces and grinding processing is performed

as-is on a large number of glass substrates using the upper and lower substrates, which have different execution pressures, a large number of glass substrates, each with different surface undulations, will be generated. In view of this, Patent Literature 4 states that even in the case of processing a large
5 number of glass substrates, glass substrates with minute and uniform undulations on the front and rear surfaces thereof can be manufactured by processing only the surfaces with large surface undulations using the upper surface plate, which has a higher execution pressure.

[0009]

10 Thus, with the conventional technique (Patent Literature 4), the upper and lower surface plates with different execution pressures, or in other words, processing rates, are used as-is to make the undulations on the front and rear surfaces of the substrate uniform, due to the undulations decreasing in size the greater the processing amount is. However, according to the studies carried
15 out by the inventor, it was found that the following problems exist.

That is to say, the processing is not stable when there is a difference in the processing rate between the upper and lower plates as in the conventional technique, and even when the technique disclosed in Patent Literature 4 was applied, when batch processing was performed continuously, a defect in which
20 the upper surface plate sides of the glass substrates were sufficiently ground but all or portions of the surfaces of the lower surface plate side were not ground occurred at a constant ratio. The glass substrates produced using the float method normally have a mirror-finished surface with a surface roughness Ra of 5 nm or less, and it was also found that the above-described defect occurred
25 significantly in the case of processing a glass substrate with such a mirror-finished surface.

[0010]

The present invention has been achieved to solve such conventional

problems, and it is a first object thereof to provide a method for manufacturing a magnetic-disk glass substrate according to which stable grinding processing in which grinding unevenness does not occur can be performed in grinding processing using fixed abrasive particles, the incidence rate of post-processing flatness defects can be reduced, and a high-quality glass substrate can be manufactured, a method for manufacturing a magnetic disk using a glass substrate obtained using the above method, and a grinding tool suitable for the above-described grinding processing.

[0011]

Also, it is a second object thereof to provide a method for manufacturing a magnetic-disk glass substrate according to which, in grinding processing using fixed abrasive particles, stable grinding processing can be performed even when there is a difference in execution pressure between upper and lower surface plates during grinding processing, and according to which a high-quality glass substrate can be manufactured, and a method for manufacturing a magnetic disk using a glass substrate obtained using the above method.

Means to Solve the Problem

[0012]

As a result of studying in detail the reason why partial grinding defects occur in the above-described conventional technique, the inventor found that minute undulations exist on the surface of the diamond pad that includes diamond abrasive particles (assembled abrasive particles), whereby the abrasive particles are impeded from coming into contact with the glass surface and abrasive particles exist that cannot sufficiently act on the glass surface, and for this reason, the above-described partial grinding defects occur. In view of this, the inventor achieved the present invention as a result of focusing on the relationship between the protrusion amount of the grinding abrasive particles

that protrude from the assembled abrasive particles and the minute undulations on the surface of the diamond pad, and searching for a solution according to which stable grinding processing can be performed.

[0013]

5 Also, as a result of studies, the inventor inferred that defects in which the processing becomes unstable when batch processing is performed continuously in the above-described conventional technique, the upper surface plate side of the glass substrate is ground significantly, and the entirety or a portion of the lower surface plate side surface is not ground occur at a constant ratio for the
10 following reasons.

 In the grinding processing, processing is performed along with a grinding liquid, but the grinding liquid is inevitably concentrated on the lower surface plate side during processing. Also, grinding chips (sludge) are generated accompanying grinding processing. In the case of using fixed abrasive
15 particles (assembled abrasive particles) in which multiple diamond abrasive particles are held together with a glass bonding material, as with the above-described diamond pad, it is thought that glass, which the grinding chips are constituted by, and which is the same material as the bonding material, is likely to attach to the glass bonding material around the abrasive particles, and
20 this occurs significantly on the lower surface plate side. Thus, the above-described defects are likely to occur.

[0014]

 Since stable grinding processing cannot be performed with the method in which upper and lower surface plates such as those used in the conventional
25 technique, which have different execution pressures, or in other words, processing rates, are used as-is, the inventor achieved the present invention as a result of searching for a solution according to which, in grinding processing using fixed abrasive particles, the processing rates of the upper and lower

surface plates can be made uniform and stable grinding processing can be performed, even in the case where there is a difference in execution pressure between the upper and lower surface plates during the grinding processing.

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

[0015]

(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
10 the grinding processing, a main surface of the glass substrate is ground using a grinding tool including an assembled abrasive particle in which a plurality of grinding abrasive particles are bonded with a glass bonding material, and resin for bonding a plurality of the assembled abrasive particles, a protrusion amount of the grinding abrasive particles on a grinding surface of the grinding tool from
15 surrounding resin being higher than a maximum height of a surface shape obtained by measuring the grinding surface using a tracer type surface roughness meter.

[0016]

(Aspect 2)

20 A method for manufacturing a magnetic-disk glass substrate including dressing processing for a grinding tool and grinding processing for grinding a main surface of a glass substrate, in which dressing processing is performed in advance such that a protrusion amount of grinding abrasive particles on a grinding surface of the grinding tool from surrounding resin is greater than a
25 maximum height of a surface shape obtained by measuring the grinding surface using a tracer type surface roughness meter, and the main surface of the glass substrate is ground using the grinding tool that was subjected to the dressing processing, the grinding tool including an assembled abrasive particle in which a

plurality of grinding abrasive particles are bonded with a glass bonding material, and resin for bonding a plurality of the assembled abrasive particles.

[0017]

(Aspect 3)

- 5 The method for manufacturing a magnetic-disk glass substrate according to Aspect 1 or 2, in which the grinding abrasive particles contain diamond abrasive particles.

(Aspect 4)

- 10 The method for manufacturing a magnetic-disk glass substrate according to any of Aspects 1 to 3, in which the grinding processing is performed on the glass substrate in a state in which the main surface is a mirror-finished surface.

[0018]

(Aspect 5)

- 15 A grinding tool for grinding a surface of a glass substrate, the grinding tool including an assembled abrasive particle in which a plurality of grinding abrasive particles are bonded with a glass bonding material, and resin for bonding a plurality of the assembled abrasive particles, a protrusion amount of the grinding abrasive particles protruding from the assembled abrasive particles
20 being greater than a maximum height of a surface shape obtained by measuring a grinding tool surface using a tracer type surface roughness meter.

[0019]

(Aspect 6)

- 25 A method for manufacturing a magnetic-disk glass substrate including grinding processing for grinding a main surface of a glass substrate by interposing the glass substrate between an upper surface plate and a lower surface plate, each having a grinding surface provided with a fixed abrasive particle grindstone in which a plurality of grinding abrasive particles are bonded

via a glass bonding material, in which dressing processing is performed under different conditions on respective surfaces of the fixed abrasive particle grindstone on the upper surface plate side and the fixed abrasive particle grindstone on the lower surface plate side, such that a difference in processing speed between the upper and lower surface plates decreases.

[0020]

(Aspect 7)

A method for manufacturing a magnetic-disk glass substrate including grinding processing for grinding a main surface of a glass substrate by interposing the glass substrate between an upper surface plate and a lower surface plate, each having a grinding surface provided with a fixed abrasive particle grindstone in which a plurality of grinding abrasive particles are bonded via a glass bonding material, in which dressing processing is performed under different conditions on respective surfaces of the fixed abrasive particle grindstone on the upper surface plate side and the fixed abrasive particle grindstone on the lower surface plate side such that a percentage of assembled abrasive particles to which sludge is not adhered is greater for the lower surface plate.

[0021]

(Aspect 8)

The method for manufacturing a magnetic-disk glass substrate according to Aspect 6 or 7, in which a time and/or frequency of the dressing processing is made different between the fixed abrasive particle grindstone on the lower surface plate side and the fixed abrasive particle grindstone on the upper surface plate side.

(Aspect 9)

The method for manufacturing a magnetic-disk glass substrate according to any of Aspects 6 to 8, in which the dressing processing is

performed using a grindstone.

[0022]

(Aspect 10)

The method for manufacturing a magnetic-disk glass substrate
5 according to any of Aspects 6 to 9, in which the fixed abrasive particle grindstone
includes diamond particles.

(Aspect 11)

The method for manufacturing a magnetic-disk glass substrate
according to any of Aspects 6 to 10, in which the grinding processing is
10 performed on the glass substrate in a state in which the main surface is a
mirror-finished surface.

[0023]

(Aspect 12)

A method for manufacturing a magnetic disk, wherein at least a
15 magnetic recording layer is formed on a magnetic-disk glass substrate
manufactured using the method for manufacturing a magnetic-disk glass
substrate according to any of Aspects 1 to 4, and 6 to 11. By grinding the main
surfaces of the glass substrate in this manner, the substrate is processed so as
to have a predetermined plate thickness and flatness and a predetermined
20 surface roughness is attained.

Effect of the Invention

[0024]

With the present invention, in grinding processing using fixed abrasive
25 particles, it is possible to perform stable grinding processing in which no grinding
unevenness occurs, and the incidence rate of post-processing flatness defects
can be reduced. Also, this makes it possible 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. Also, a grinding tool suitable for the above-described grinding processing can be provided.

Also, with the present invention, it is possible to perform stable grinding processing using fixed abrasive particles, even if there is a difference in
5 execution pressure between upper and lower surface plates during the grinding processing. This makes it possible to manufacture a high-quality glass substrate. Also, a magnetic disk with high reliability can be manufactured using the thus-obtained glass substrate.

10 Brief Description of Drawings

[0025]

FIG. 1 is a schematic cross-sectional view showing a configuration of a diamond pad used in the present invention.

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

15

Description of Embodiments

[0026]

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

20 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
25 sheet of glass manufactured using a float method or a downdraw method into a predetermined size. 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.

[0027]

Next, grinding processing for improving dimensional accuracy and shape accuracy is performed on the glass substrate.

5 With this grinding processing, a double-side grinding apparatus is normally used to perform grinding of the main surfaces of the glass substrate using hard abrasive particles, such as diamond. By grinding the main surfaces of the glass substrate in this manner, the substrate is processed so as to have a predetermined plate thickness and flatness and a predetermined surface
10 roughness is attained.

[0028]

The present invention relates to an improvement in the grinding processing. The grinding processing of the present invention is grinding processing using a grindstone that includes diamond assembled abrasive
15 particles, for example, as fixed abrasive particles, and in a double-side grinding apparatus, a glass substrate held by a carrier is tightly placed between upper and lower surface plates to which diamond pads serving as grinding tools are attached, for example, then the glass substrate and the upper and lower surface plates are moved relative to one another while the glass substrate is furthermore
20 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 surfaces affected by the processing and promote the processing.

[0029]

25 The grinding tool (fixed abrasive particle grindstone) used in the grinding processing of the present invention is, for example, a diamond pad, an overall configuration of which is shown in FIG. 1. Abrasive particle aggregates (referred to as “assembled abrasive particles” in the present invention) 3, in

which several diamond particles 5 (see FIG. 2) are held together with a bonding material such as glass, are attached to a sheet 2 using a supporting material such as resin (e.g., acrylic resin or the like), thus forming the diamond pad 1 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 assembled abrasive particles on a sheet and thereafter forming grooves in the resin layer so as to form protruding shapes may be used.

10 [0030]

It should be noted that “fixed abrasive particles” mentioned in the present embodiment refer to grinding abrasive particles fixed in a grindstone (grinding tool), such as the above-described assembled abrasive particles, unless particularly stated otherwise, and “average particle diameter of abrasive particles” refers to the average particle diameter of the above-described grinding abrasive particles.

[0031]

(First Embodiment)

As described above as well, the inventor studied in detail the reason why partial grinding defects occur in the above-described conventional technique, and as a result, found that the above-described partial grinding defects occur because minute undulations exist on the surface of the diamond pad, which includes the diamond abrasive particles (assembled abrasive particles), and thus the abrasive particles are inhibited from coming into contact with the glass surface, and particles that cannot sufficiently act on the glass surface exist. In view of this, as a result of intensive studies with a focus on the relationship between a protrusion amount of grinding abrasive particles that protrude from the assembled abrasive particles and minute undulations on the surface of the

diamond pad, the inventor found that stable grinding processing can be performed by performing grinding using a diamond pad (grinding tool) in which the protrusion amount of the grinding abrasive particles protruding from the assembled abrasive particles is higher than the minute undulations on the surface of the diamond pad.

[0032]

That is to say, the grinding processing of the present invention is such that, as described in Aspect 1, a main surface of a glass substrate is ground using a grinding tool including an assembled abrasive particle in which a plurality of grinding abrasive particles are bonded with a glass bonding material, and resin for bonding a plurality of the assembled abrasive particles, a protrusion amount of the grinding abrasive particles on a grinding surface of the grinding tool from surrounding resin being higher than a maximum height of a surface shape obtained by measuring the grinding surface using a tracer type surface roughness meter.

[0033]

For example, if a grinding tool is used in which the above-described protrusion amount of the grinding abrasive particles is lower than the maximum height of the surface shape, the abrasive particles will be inhibited from coming into contact with the glass surface due to the minute undulations existing on the surface of the grinding tool, and many abrasive particles will not be able to sufficiently act on the glass surface (will have a weak effect on the glass surface), and therefore the above-described partial grinding defects will occur, and the incidence rate of post-processing flatness defects will increase as a result.

Also, using a grinding tool in which the protrusion amount of the grinding abrasive particles is equal to the maximum height of the surface shape will somewhat solve the problem of the abrasive particles being inhibited from coming into contact with the glass surface due to the minute undulations existing

on the surface of the grinding tool, but it should be noted that abrasive particles that cannot sufficiently act on the glass surface will still exist, and therefore grinding unevenness will occur in portions, and it will not be possible to significantly reduce the incidence rate of post-processing flatness defects as a result.

[0034]

Accordingly, if a grinding tool is used in which the protrusion amount of grinding abrasive particles is greater than the maximum height of the surface shape as with the present invention, the abrasive particles will no longer be inhibited from coming into contact with the glass surface, even if there are minute undulations on the surface of the grinding tool, and therefore the grinding abrasive particles will stably act on the glass surface, and it will be possible to perform stable grinding processing with no grinding unevenness. As a result, it is therefore also possible to improve the post-processing flatness defect rate to 0%, for example.

[0035]

In the present invention, the maximum height of the surface shape of the above-described grinding tool is defined as the maximum elevation difference R_z (JIS B 0601:2001) on a line roughness curve measured using a tracer type surface roughness meter on the grinding surface of the grinding tool surface, and is an index for the size of minute undulations that exist on the surface of the grinding tool. It should be noted that the measurement width (measurement length) in this case is preferably 2 to 3 mm on the grinding tool surface. It was found that if the measurement width is smaller than the above-described range, only the surface roughness near the abrasive particles will be measured, and in this case, grinding particles with relatively high hardness will have the highest roughness. For this reason, such a measurement width is not suitable as the measurement range for managing whether or not the abrasive particles focused

on in the present invention will have an effect. On the other hand, if the measurement width is too large, the flatness (undulations) of the entire grinding tool will also be measured, and therefore a measurement width that is too large is not suitable for defining the relationship with the protrusion amounts of the grinding abrasive particles. In the present invention, the measurement width is 2.5 mm. Also, it is essential that the measurement location is the grinding surface of the grinding tool surface that comes into contact with the surface of the processing target substrate, and therefore if a groove or the like is formed on the surface of the grinding surface, it goes without saying that measurement will not be performed on that portion.

[0036]

Also, in the present invention, the protrusion amount of the grinding abrasive particles on the above-described grinding tool is measured as follows.

When the distance from the inner circumference to the outer circumference of the respective grinding tools (normally formed into disk shapes) of the upper and lower surface plates before carrying out the grinding processing is set to 100%, a total of six 2.5 mm × 2.5 mm samples (pad fragments) are cut out from the positions of 10%, 50%, and 90% from the inner circumference. For each of these six samples, with respect to five assembled particles selected randomly from an observation image (surface shape data) obtained using a laser microscope (using a greater number of samples improves the protrusion amount measurement accuracy, but takes an extremely large number of man-hours, which is not practical, but on the other hand, if the number of samples is less than five, the protrusion amount measurement accuracy significantly decreases, which is problematic in terms of management, and therefore, five is suitable as the number of measurement samples according to which it is possible to achieve both productivity and product quality stabilization), the maximum elevation difference between the assembled abrasive particles

and the resin portions around the assembled abrasive particles are measured by cross-sectional shape analysis or the like, and the protrusion amount of the grinding abrasive particles on the grinding tools on the surface plates is defined as the average value of the elevation differences of all the assembled abrasive particles. It should be noted that the protrusion amounts are adjusted such that they are almost equal on the upper and lower surface plates.

[0037]

By performing dressing processing with a grindstone, for example, it is possible to perform adjustment to obtain a grinding tool managed such that the protrusion amount of the grinding abrasive particles of the present invention is greater than the maximum height of the surface shape. Specifically, for example, the double-side grinding apparatus used in the grinding processing is applied in the dressing processing as well, and the dressing processing can be performed in a state where a grindstone that has a grit number of #400 to #3000 and is managed to obtain a suitable thickness variation is brought into contact with the surfaces of grinding tools such as diamond pads disposed on the upper and lower surface plates, and the upper and lower surface plates of the double-side grinding apparatus are rotated. The smaller the grit number is, the more the protrusion amount can be increased by removing the resin near the fixed abrasive particles.

On the other hand, the maximum height of the minute undulations on the grinding tool surface can be adjusted by appropriately changing the maximum height of the minute undulations on the grindstone surface used in the dressing processing. The smaller the maximum height of the minute undulations on the surface of the grindstone for dressing processing is, the smaller the maximum height of the minute undulations on the surface of the grinding tool after the dressing processing will be. Specifically, it is sufficient that processing is performed using a grindstone for dressing processing having a value that is

smaller than the target value for the maximum height of the minute undulations on the grinding tool surface.

[0038]

It is sufficient that the rotation rate of the surface plates is selected as appropriate from a range of 1 to 30 rpm, and the surface plate load applied to the grindstone for dressing is selected as appropriate from a range of 10 to 200 g/cm². Although there is no particular limitation on the material of the grindstone to be used in the dressing processing, it is preferable to use an alumina grindstone or the like, for example. Also, a configuration is possible in which dressing processing is performed in a stepwise manner using multiple grindstones for dressing with different grit numbers and minute undulations. For example, the protrusion amount of the grinding tool surface is first adjusted using a grindstone for dressing with a small grit number and large minute undulations, and thereafter, the height of the minute undulations on the grinding tool surface is adjusted using a grindstone for dressing with a large grit number and small minute undulations, which makes it easier to obtain the desired properties of the grinding tool surface. The minute undulations of the grindstone for dressing processing can be measured similarly to the minute undulations of the grinding tool surface.

[0039]

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 1.5 to 12 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 deep enough, 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.

[0040]

Also, the present invention is particularly preferable in the case of using grinding abrasive particles with an average particle diameter of 3.0 μm or less. In the conventional technique, if such grinding abrasive particles with small diameters were used, the grinding abrasive particles could not stably act on the glass substrate, and the occurrence of the above-described grinding unevenness was prominent. However, according to the present invention, the grinding tool managed such that the protrusion amount of the grinding abrasive particles is higher than the maximum height of the surface shape of the grinding tool is applied, and therefore such conventional problems can be solved.

Also, the average particle diameter of the assembled grinding particles is preferably 15 to 50 μm . If the average particle diameter is smaller than the above-described range, it is particularly difficult to cause the abrasive particles to cut into the surface of the mirror-finished glass substrate at the start of the processing, and the grinding rate deteriorates in some cases. Also, if the average particle diameter is greater than the above-described range, the surface roughness resulting from grinding becomes excessively high in some cases.

[0041]

It should be noted that in the present invention, the above-mentioned average particle diameter denotes a particle diameter at which a cumulative curve reaches 50% when the cumulative curve is determined by setting the overall volume of powder particles in the particle size distribution measured using a laser diffraction method to 100% (hereinafter referred to as "cumulative average particle diameter (50% diameter)"). 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.

[0042]

In the grinding processing of the present invention, the load during processing is preferably 100 g/cm^2 to 150 g/cm^2 . If the processing load falls below the above-described range, the abrasive particles do not act on the mirror-finished glass substrate surface, and it becomes difficult for the grinding to advance. On the other hand, if the processing load exceeds the above-described range, the abrasive particles cut into the glass more, and therefore there is a risk that the finishing roughness will increase and the machining allowance load in a subsequent step will increase.

10 [0043]

(Second Embodiment)

The second embodiment of the grinding processing according to the present invention is such that in the grinding processing for grinding a main surface of a glass substrate by interposing the glass substrate between an upper surface plate and a lower surface plate, each having a grinding surface provided with a fixed abrasive particle grindstone in which a plurality of grinding abrasive particles are bonded via a glass bonding material, dressing processing is performed under different conditions on respective surfaces of the fixed abrasive particle grindstone on the upper surface plate side and the fixed abrasive particle grindstone on the lower surface plate side, such that a difference in processing speed between the upper and lower surface plates decreases.

[0044]

As described before as well, processing is not stable when there is a difference in processing rate between the upper and lower surface plates, as in the conventional technique, and when batch processing is performed continuously, a defect occurs in which the upper surface plate side of the glass substrate is sufficiently ground but the entirety or a portion of the surface on the lower surface plate side is not ground. In particular, the above-described defect

occurs significantly in the case of processing a mirror-finished glass substrate such as a glass substrate produced using a float method.

[0045]

According to studies carried out by the inventor, in the case of using
5 fixed abrasive particles (assembled abrasive particles) in which multiple
diamond abrasive particles are held together with a glass bonding material, for
example, as with the above-described diamond pad, it is thought that glass,
which the grinding chips that are generated accompanying the processing are
constituted by, is likely to attach to the glass bonding material around the
10 abrasive particles, and this occurs significantly on the lower surface plate side on
which the grinding liquid tends to be concentrated. Thus, the above-described
defect is likely to occur.

[0046]

Stable grinding processing cannot be performed with the conventional
15 method in which upper and lower plates with different execution pressures, or in
other words, processing rates, are used as-is, and therefore, as a result of
searching for a solution according to which, in grinding processing using fixed
abrasive particles, stable grinding processing can be performed even when
there is a difference in execution pressure between the upper and lower surface
20 plates during grinding processing, the inventor found that it is preferable to
perform the dressing processing under different conditions on the respective
surfaces of the fixed abrasive particle grindstone on the upper surface plate side
and the fixed abrasive particle grindstone on the lower surface plate side, such
that the difference in processing speed between the upper and lower surface
25 plates is reduced.

[0047]

As the above-described dressing processing, it is preferable to use
processing for removing attached grinding chips from the surfaces of the fixed

abrasive particle grindstones. Also, although the dressing processing is performed under different conditions on the respective surfaces of the fixed abrasive particle grindstone on the upper surface plate side and the fixed abrasive particle grindstone on the lower surface plate side such that the difference in processing speed between the upper and lower surface plates decrease, in this case, it is preferable to perform removal processing in which the amount of grinding chips removed from the surface of the fixed abrasive particle grindstone disposed on the lower surface plate side is greater in comparison to that of the fixed abrasive particle grindstone disposed on the upper surface plate side.

[0048]

Specifically, the double-side grinding apparatus used in the grinding processing can be applied to the dressing processing as well, and the dressing processing can be performed in a state in which a grindstone with a grit number of about #400 to 3000, for example, is brought into contact with the fixed abrasive particle surfaces and the upper and lower surface plates of the double-side grinding apparatus are rotated. Although there is no particular limitation on the material of the grindstone to be used in the dressing processing, it is preferable to use an alumina grindstone, a silicon carbide grindstone, or the like, for example.

[0049]

In the present invention, it is important to perform the dressing processing under different conditions on the respective surfaces of the fixed abrasive particle grindstone on the upper surface plate side and the fixed abrasive particle grindstone on the lower surface plate side such that the difference in processing speed between the upper and lower surface plates decreases, and in order to achieve this, conditions such as the surface plate rotation rate at the time of dressing processing, the processing time, and the

number of instances of processing (frequency) are made different between the upper and lower plates. Accordingly, it is possible to perform removal processing in which the amount of grinding chips removed from the surface of the fixed abrasive particle grindstone disposed on the lower surface plate side is greater in comparison to that of the fixed abrasive particle grindstones disposed on the upper surface plate side.

[0050]

For example, a range of about 10 to 50 rpm is suitable as the surface plate rotation rate at the time of the above-described dressing processing, and in the case of changing the condition of the rotation rate at the time of dressing processing between the upper and lower surface plates, the rotation rate of the lower surface plate is made faster than the rotation rate of the upper rotation plate.

For example, a range of about 5 to 120 seconds is suitable as the above-described dressing processing time, and in the case of changing the condition of the dressing processing time between the upper and lower surface plates, the processing time of the lower surface plate is set to be longer than the processing time of the upper surface plate. For example, the processing time of the upper surface plate can be set within a range of 5 to 60 seconds, and the processing time of the lower surface plate can be set within a range of 20 to 120 seconds. In this case, the ratio of the processing times of the upper and lower surface plates is preferably set such that upper surface plate : lower surface plate = 4:5 to 1:2.

[0051]

Also, as the above-described number of instances of dressing processing (frequency), it is suitable to perform the dressing processing each time 10 to 100 batches (100 substrates per batch) are processed in succession. In the case of changing the condition of the number of instances of dressing

processing for the upper and lower plates, the upper surface plate undergoes the dressing processing every time 20 to 100 batches are processed in succession, and the lower surface plate undergoes the dressing processing every time 10 to 50 batches are processed in succession. In this case, the ratio of the numbers of instances of processing of the upper and lower surface plates is preferably set such that upper surface plate : lower surface plate = 4:5 to 1:2.

It should be noted that it is not necessary to make all of the conditions such as the surface plate rotation rate at the time of dressing processing, the processing time, and the number of instances of processing (frequency) different between the upper and lower surface plates. A configuration may be used in which at least any one condition is made different.

The dressing processing conditions can be set such that the difference in processing speed between the upper and lower surface plates decreases, and such that, for example, the percentage of effective abrasive particles after the dressing processing (can be checked using a microscope) reaches a suitable proportion between the upper and lower surface plates.

[0052]

In the present invention, the above-described fixed 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 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 deep enough, 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.

[0053]

In the present invention, the surface of the glass substrate to be introduced to the grinding processing is preferable in the case of being in a mirror-finished state in which Ra is 5 nm or less. In the case of using a grinding tool in which fixed abrasive particles are dispersed, such as a diamond pad, a certain number or more of the grinding abrasive particles need to cut into the surface of the processing target substrate at the same time, but this is difficult to achieve because the lower the roughness of the processing target substrate is, the easier it is to be influenced by minute undulations on the grinding tool surface. In the conventional technique, the above-described grinding unevenness was prominent when a glass substrate with a mirror-finished surface produced by a float method or the like was ground, but with the present invention, such a conventional problem can be solved.

Also, in the present invention, the surface of the glass substrate after the end of the grinding processing is preferably finished such that the surface roughness Ra is in a range of 0.080 to 0.130 μm . By suppressing the finishing roughness to a low level in this manner, the processing load on a subsequent step can be reduced.

[0054]

With 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 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 in an amount 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.

[0055]

Also, as heat-resistant glass to be used in a next-generation magnetic disk for heat-assisted magnetic recording, it is possible to preferably use glass that contains, for example, 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 $[\text{Al}_2\text{O}_3/(\text{MgO}+\text{CaO})]$ in a range of 0 to 0.30.

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 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.

[0056]

After the above-described grinding processing ends, mirror-polishing processing 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 amount removed in the subsequent mirror-polishing processing is small, the processing load is reduced, and it is possible to reduce the processing cost.

5 [0057]

The method for performing mirror-polishing on the glass substrate is preferably performed using polishing pads of a polisher such as polyurethane 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
10 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 abrasive particles (second polishing processing).

[0058]

15 In the present invention, the surface of the glass substrate subjected to the above-mentioned mirror-polishing processing is preferably a mirror-finished surface with an arithmetic mean surface roughness Ra of 0.2 nm or less, and more preferably 0.1 nm or less. It should be noted that “arithmetic mean roughness Ra” in the present invention refers to a roughness calculated in
20 accordance with Japanese Industrial Standard (JIS) B 0601.

Also, in the present invention, it is preferable in terms of practical use that the surface roughness (above-described arithmetic mean roughness Ra) is the surface roughness of a surface shape obtained when a 5- μ m square is measured at a resolution of 256x256 with an atomic force microscope (AFM).

25 [0059]

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 temperature of the glass transition point, for example. The chemical strengthening processing is processing in which a glass substrate is brought into contact with a molten chemical strengthening salt so that an alkali metal element having a relatively large atomic radius in the chemical strengthening salt and an alkali metal element having a relatively small atomic radius in the glass substrate are ion-exchanged, whereby the alkali metal element having a relatively large ionic radius permeates through the surface layer or the glass substrate, and compressive stress is generated on the surface of the glass substrate. A glass substrate subjected to chemical strengthening has excellent impact resistance, and therefore, it is particularly preferable to mount the glass substrate on an HDD for mobile use, for example.

[0060]

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.

[0061]

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

The magnetic-disk glass substrate obtained according to the present invention can be used to obtain a magnetic disk with high reliability.

Working Examples

5 [0062]

Embodiments of the present invention will be described specifically through working examples below. It should be noted that the present invention is not limited to the following working examples.

(Working Example 1-1)

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

15 [0063]

(1) Substrate preparation

Large sheet glass made of aluminosilicate glass with a thickness of 1 mm manufactured using a float method was prepared and cut into small 70 mm × 70 mm square pieces using a diamond cutter. Next, the diamond cutter was
20 used to process the square pieces into disk shapes with an outer diameter of 65 mm and an inner diameter of 20 mm. As this aluminosilicate glass, amorphous glass capable of being chemically strengthened and containing SiO₂ in an amount of 62 to 75 wt%, ZrO₂ in an amount of 5.5 to 15 wt%, Al₂O₃ in an amount of 5 to 15 wt%, Li₂O in an amount of 4 to 10 wt%, and Na₂O in an amount of 4 to
25 12 wt% was used.

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

[0064]

(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 on the outer circumferential edge surface and the inner circumferential edge
5 surface.

(3) Edge surface polishing

Next, the edge surfaces (inner and outer circumferential edge surfaces) of the glass substrate were polished by brushing while the glass substrate was rotated.
10 [0065]

(4) Main surface grinding processing

A glass substrate held by a carrier was set between upper and lower surface plates to which fixed abrasive particle grindstones (diamond pads) were attached so as to perform the main surface grinding processing using a
15 double-side grinding apparatus, the fixed abrasive particle grindstones (diamond pads) including assembled abrasive particles in which multiple diamond abrasive particles were held together using a glass bonding material, and resin for bonding the multiple assembled abrasive particles. Diamond pads with diamond abrasive particles having an average particle diameter (D50) of about
20 3.0 μm and assembled abrasive particles having an average particle diameter (D50) of 30 μm were used. Processing was performed while a lubricating liquid was used. Also, the rotation rate of the surface plates and the load applied to the glass substrate was adjusted as appropriate.

Before the grinding processing, dressing processing was performed
25 using an alumina grindstone. When the protrusion amounts of the grinding abrasive particles on the above-described diamond pads used in the present working example and the maximum heights of the surface shapes (minute undulations) were measured with the above-described method, the protrusion

amount of the grinding abrasive particles was 2 μm , and the maximum height of the surface shape was 0.5 μm .

[0066]

(5) Main surface polishing (first polishing)

5 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 polishing surface plates to which polishing pads have been attached, the carrier
10 is engaged with the sun gear and the internal gear, and the glass substrate is pressed between the upper and lower surface plates. Then, a polishing liquid is supplied between the polishing pads and the glass substrate surfaces to be polished, the upper and lower surface plates are rotated, and thus the glass substrate revolves while rotating on the surface plates so that both surfaces of
15 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 a polishing agent was used as the polishing liquid, and the load and polishing time were set as appropriate. The glass substrate that was subjected to the above-described first polishing
20 processing was immersed in cleaning tanks of a neutral detergent, pure water, IPA (isopropyl alcohol), and IPA (vapor drying) in sequence, subjected to ultrasound cleaning, and dried.

[0067]

(6) Chemical strengthening

25 Next, chemical strengthening was performed on the glass substrate that was subjected to the above-described cleaning. Chemical strengthening 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.

[0068]

(7) Main surface polishing (second polishing)

5 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) was used instead as the polisher. This second polishing is mirror-polishing processing to finish the main surfaces of the glass substrate into smooth mirror-finished surfaces
10 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. After completing the second polishing step, the glass substrate was immersed in
15 cleaning tanks of a neutral detergent, pure water, IPA, and IPA (vapor drying) in sequence, subjected to ultrasound cleaning, and dried.

[0069]

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

[0070]

(Working Example 1-2)

A magnetic-disk glass substrate was produced by performing grinding
25 processing similarly to Working Example 1-1, except that in the main surface grinding processing of Working Example 1-1, diamond pads were used in a state in which the average particle diameter of the diamond abrasive particles was about 9.0 μm , the protrusion amount of the grinding abrasive particles was 7 μm ,

and the maximum height of the surface shape was 5 μm .

(Working Example 1-3)

A magnetic-disk glass substrate was produced by performing grinding processing similarly to Working Example 1-1, except that in the main surface grinding processing of Working Example 1-1, diamond pads were used in a state
5 in which the average particle diameter of the diamond abrasive particles was about 1.5 μm , the protrusion amount of the grinding abrasive particles was 3 μm , and the maximum height of the surface shape was 1 μm .

[0071]

10 (Working Example 1-4)

A magnetic-disk glass substrate was produced by performing grinding processing similarly to Working Example 1-1, except that in the main surface grinding processing of Working Example 1-1, diamond pads were used in a state in which the average particle diameter of the diamond abrasive particles was
15 about 1.5 μm , the protrusion amount of the grinding abrasive particles was 2 μm , and the maximum height of the surface shape was 0.5 μm .

(Working Example 1-5)

A magnetic-disk glass substrate was produced by performing grinding processing similarly to Working Example 1-1, except that in the main surface grinding processing of Working Example 1-1, diamond pads were used in a state
20 in which the average particle diameter of the diamond abrasive particles was about 12 μm , the protrusion amount of the grinding abrasive particles was 9 μm , and the maximum height of the surface shape was 6 μm .

[0072]

25 (Comparative Example 1-1)

A magnetic-disk glass substrate was produced by performing grinding processing similarly to Working Example 1-1, except that in the main surface grinding processing of Working Example 1-1, diamond pads were used in a state

in which the average particle diameter of the diamond abrasive particles was about 3.0 μm , the protrusion amount of the grinding abrasive particles was 2 μm , and the maximum height of the surface shape was 2 μm .

(Comparative Example 1-2)

5 A magnetic-disk glass substrate was produced by performing grinding processing similarly to Working Example 1-1, except that in the main surface grinding processing of Working Example 1-1, diamond pads were used in a state in which the average particle diameter of the diamond abrasive particles was about 3.0 μm , the protrusion amount of the grinding abrasive particles was 2 μm ,
10 and the maximum height of the surface shape was 3 μm .

[0073]

(Comparative Example 1-3)

 A magnetic-disk glass substrate was produced by performing grinding processing similarly to Working Example 1-1, except that in the main surface
15 grinding processing of Working Example 1-1, diamond pads were used in a state in which the average particle diameter of the diamond abrasive particles was about 3.0 μm , the protrusion amount of the grinding abrasive particles was 2 μm , and the maximum height of the surface shape was 5 μm .

(Comparative Example 1-4)

20 A magnetic-disk glass substrate was produced by performing grinding processing similarly to Working Example 1-1, except that in the main surface grinding processing of Working Example 1-1, diamond pads were used in a state in which the average particle diameter of the diamond abrasive particles was about 9.0 μm , the protrusion amount of the grinding abrasive particles was 7 μm ,
25 and the maximum height of the surface shape was 7 μm .

[0074]

(Comparative Example 1-5)

A magnetic-disk glass substrate was produced by performing grinding

processing similarly to Working Example 1-1, except that in the main surface grinding processing of Working Example 1-1, diamond pads were used in a state in which the average particle diameter of the diamond abrasive particles was about 9.0 μm , the protrusion amount of the grinding abrasive particles was 7 μm ,
5 and the maximum height of the surface shape was 8 μm .

(Comparative Example 1-6)

A magnetic-disk glass substrate was produced by performing grinding processing similarly to Working Example 1-1, except that in the main surface grinding processing of Working Example 1-1, diamond pads were used in a state
10 in which the average particle diameter of the diamond abrasive particles was about 9.0 μm , the protrusion amount of the grinding abrasive particles was 7 μm , and the maximum height of the surface shape was 10 μm .

[0075]

(Comparative Example 1-7)

15 A magnetic-disk glass substrate was produced by performing grinding processing similarly to Working Example 1-1, except that in the main surface grinding processing of Working Example 1-1, diamond pads were used in a state in which the average particle diameter of the diamond abrasive particles was about 1.5 μm , the protrusion amount of the grinding abrasive particles was 2 μm ,
20 and the maximum height of the surface shape was 2 μm .

[0076]

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

25 In the above-described working examples, with regard to the glass substrates subjected to the grinding processing, a flatness tester was used to perform measurement of the flatness of 20 glass substrates per batch, and using a predetermined reference (3 μm or less) as being acceptable, the incidence

rate of glass substrates that do not satisfy the reference (flatness defect incidence rate) was calculated, and the results are shown in Table 1. Also, with regard to the glass substrates resulting from the grinding processing, the results of the surface roughness (Ra) measured by AFM are shown in Table 2 as percentages calculated using the value of Working Example 1 as a reference.

Also, in the above-described comparative examples, similarly to the above-described working examples, the flatnesses of 20 glass substrates subjected to the grinding processing per batch were measured using a flatness tester, the incidence rates (flatness defect incidence rate) of glass substrates exceeding a predetermined reference (3 μm or less) were calculated, and the results are shown in Table 1.

It should be noted that in Table 1, the grinding abrasive particle diameter is the average particle diameter (D50) of diamond minute particles included in the assembled abrasive particles, and the abrasive particle protrusion amount is the distance that the assembled abrasive particles protrude from the plane composed of the surrounding resin portion.

[0077]

[Table 1]

Table 1	Grinding abrasive particle diameter (μm)	Abrasive particle protrusion amount (A) (μm)	Maximum height (B) (μm)	A-B (μm)	Flatness defects (%)
Working Example 1-1	3.0	2	0.5	1.5	0
Comparative Example 1-1	3.0	2	2	0	20
Comparative Example 1-2	3.0	2	3	-1	80
Comparative Example 1-3	3.0	2	5	-3	100
Working Example 1-2	9.0	7	5	2	0
Comparative Example 1-4	9.0	7	7	0	10
Comparative Example 1-5	9.0	7	8	-1	40
Comparative Example 1-6	9.0	7	10	-3	80
Working Example 1-3	1.5	3	1	2	0
Working Example 1-4	1.5	2	0.5	1.5	0
Comparative Example 1-7	1.5	2	2	0	40
Working Example 1-5	12.0	9	6	3	0

[0078]

[Table 2]

Table 2	Grinding abrasive particle diameter (μm)	Abrasive particle protrusion amount (A) (μm)	Maximum height (B) (μm)	A-B (μm)	Surface roughness Ra ratio
Working Example 1-1	3.0	2	0.5	1.5	1
Working Example 1-2	9.0	7	5	2	4
Working Example 1-4	1.5	2	0.5	1.5	0.8

5 [0079]

The following can be understood from the results shown in Table 1 and Table 2 above.

1. In a comparative example in which fixed abrasive particle
grindstones with a grinding abrasive particle protrusion amount that is lower than
the maximum height of the surface shape were used in the case of a grinding
abrasive particle diameter of 3.0 μm , the effect of the grinding abrasive particles
5 on the glass surface was weak, and flatness defects had a 100% incidence rate.
Also, in a comparative example in which the protrusion amount of the grinding
abrasive particles was equal to the maximum height of the surface shape, the
flatness defect incidence rate decreased to 20%, but since there are abrasive
particles that cannot sufficiently act on the glass surface, grinding unevenness
10 occurred in portions. In contrast to this, in Working Example 1-1 in which fixed
abrasive particle grindstones with a grinding abrasive particle protrusion amount
that is higher than the maximum height of the surface shape were used, the
grinding abrasive particles stably act on the glass surface, the flatness defect
incidence rate is 0%, and stable grinding processing with no grinding
15 unevenness can be performed.

2. Also, in Working Example 1-2 in which fixed abrasive particle
grindstones with a grinding abrasive particle protrusion amount that is higher
than the maximum height of the surface shape due to the maximum height being
5 μm and the grinding abrasive particle protrusion amount being 7 μm were used
20 also in the case where the grinding abrasive particle diameter is 9.0 μm , the
grinding abrasive particles stably act on the glass substrate, and the flatness
defect incidence rate is 0%. It should be noted that in this case, the
post-processing surface roughness of the substrate is higher compared to that of
Working Example 1-1 (see Table 2). This is thought to be caused by the
25 grinding force acting on the glass surface being large due to the abrasive particle
diameter being large. On the other hand, in Comparative Examples 1-5 and
1-6 as well, in which the grinding abrasive particle diameter was 9.0 μm and
fixed abrasive particle grindstones with a grinding abrasive particle protrusion

amount that is lower than the maximum height of the surface shape were used, the effect of the grinding abrasive particles on the glass surface was weak, and the flatness defects had an incidence rate of 80%.

3. Letting the abrasive particle protrusion amount be A and the maximum height of minute undulations on the grinding surface be B, upon comparing examples in which values obtained by subtracting B from A are the same, the defect rate tends to increase when the particle diameter of the grinding abrasive particles (diamond minute particles) is 3 μm or less. That is, it is understood that the present invention is particularly effective in the case where the particle diameter of the grinding abrasive particles (diamond minute particles) is 3 μm or less.

[0080]

(Working Example 2-1)

- A magnetic-disk glass substrate of the working example below was manufactured through the same steps as in the above-described Working Example 1-1.

(1) Substrate preparation

- Large sheet glass made of amorphous aluminosilicate glass with a thickness of 1 mm manufactured using a float method was prepared and cut into small 70 mm $\times$ 70 mm square pieces using a diamond cutter. Next, the diamond cutter was used to process the square 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 chemically 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.

[0081]

(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 on the outer circumferential edge surface and the inner circumferential edge surface.

5 (3) Edge surface polishing

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

[0082]

10 (4) Main surface grinding processing

A glass substrate held by a carrier was set between upper and lower surface plates to which fixed abrasive particle grindstones (diamond pads) were attached so as to perform the main surface grinding processing using a double-side grinding apparatus, the fixed abrasive particle grindstones including aggregate abrasive particles in which multiple diamond particles were held together with a glass bonding material,. Diamond pads with diamond abrasive particles having an average particle diameter (D50) of about 2.5 μm and assembled abrasive particles having an average particle diameter (D50) of 25 μm were used. Processing was performed while a lubricating liquid was used.

20 Also, the rotation rate of the surface plates and the load applied to the glass substrate was adjusted as appropriate.

[0083]

Partway through the grinding processing, dressing processing of the above-described fixed abrasive particle grindstones was performed.

25 Specifically, brushing was first performed in order to remove grinding liquid and sludge attached to the fixed abrasive particle surfaces. Next, dressing processing was performed in a state where an alumina grindstone with a grit number of #1000 was brought into contact with the fixed abrasive particle

surfaces and the upper and lower surface plates of the above-described double-side grinding apparatus were rotated. The surface plate rotation rate at the time of dressing processing, the processing time, and the number of instances of processing (frequency) were set as follows.

5 Surface plate rotation rate: 20 rpm (same for both the upper and lower surface plates)

 Processing time (for one instance): upper surface plate – 60 seconds, lower surface plate – 120 seconds.

 Processing frequency: upper surface plate – each time 20 batches (100
10 substrates per batch) are processed in succession, lower surface plate – each time 20 batches are processed in succession.

[0084]

 (5) Main surface polishing (first polishing)

 Next, first polishing for removing blemishes and distortion remaining
15 after the above-described grinding processing was performed similarly to Working Example 1-1.

 (6) Chemical strengthening

 Next, chemical strengthening was performed similarly to Working
Example 1-1 on the glass substrate that was subjected to the above cleaning.

20 (7) Main surface polishing (second polishing)

 Next, second polishing was performed similarly to the above-described Working Example 1-1.

[0085]

 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).

[0086]

(Working Example 2-2)

In the main surface grinding processing of Working Example 2-1, the surface plate rotation rate at the time of dressing processing, the processing time, and the number of instances of processing (frequency) were set as follows.

5 Surface plate rotation rate: 20 rpm (same for both the upper and lower surface plates)

Processing time (for one instance): upper surface plate – 10 seconds, lower surface plate – 20 seconds.

Processing frequency: upper surface plate – each time 40 batches are
10 processed in succession, lower surface plate – each time 20 batches are processed in succession.

Other than that, magnetic-disk glass substrates were manufactured similarly to Working Example 2-1.

[0087]

15 (Working Example 2-3)

In the main surface grinding processing of Working Example 2-1, the surface plate rotation rate at the time of dressing processing, the processing time, and the number of instances of processing (frequency) were set as follows.

Surface plate rotation rate: 20 rpm (same for both the upper and lower
20 surface plates)

Processing time (for one instance): upper surface plate – 10 seconds, lower surface plate – 20 seconds.

Processing frequency: upper surface plate – each time 100 batches are
processed in succession, lower surface plate – each time 50 batches are
25 processed in succession.

Other than that, magnetic-disk glass substrates were manufactured similarly to Working Example 2-1.

[0088]

(Comparative Example 2-1)

In the main surface grinding processing of Working Example 2-1, the surface plate rotation rate at the time of dressing processing, the processing time, and the number of instances of processing (frequency) were set as follows.

5 Surface plate rotation rate: 20 rpm (same for both the upper and lower surface plates)

 Processing time (one instance): upper surface plate – 10 seconds, lower surface plate – 10 seconds (same for both the upper and lower surface plates)

 Processing frequency: upper surface plate – each time 50 batches are
10 processed in succession, lower surface plate – each time 50 batches are processed in succession (same for both the upper and lower surface plates).

 Other than that, magnetic-disk glass substrates were manufactured similarly to Working Example 2-1.

[0089]

15 Table 3 shows the results of studying the percentage of assembled abrasive particles (assembled abrasive particles to which sludge is not adhered) that effectively act on the upper and lower surface plates at the time of ending the dressing processing after the main surface grinding step has been performed on 200 batches in the above-described working examples and
20 comparative examples. It should be noted that in the case where sludge covered almost all of the assembled abrasive particles, it was determined that sludge was adhered, and in the case where sludge was attached to a small number of the assembled abrasive particles, it was not determined that sludge was adhered.

25 It should be noted that the percentage of effective fixed abrasive particles was checked by microscopically observing the diamond pad surfaces and observing a certain number (100 for each of the upper and lower surface plates) of fixed abrasive particle.

Table 3 also shows the ratio between the processing speeds of the upper and lower surface plates (lower surface plate processing speed / upper surface plate processing speed) during the 201st batch. The ratio between the processing speeds is more preferable the closer to 1 it is, but when the ratio is

5 1.05 to 0.95, the processing balance of the upper and lower surface plates improves, and stable processing can be performed continuously.

[0090]

After the main surface grinding step has ended, the frequency with which defects occur in a state in which all or a portion of the substrate surface on

10 the lower surface plate side has not been processed is expressed as a defective batch percentage, and the results are shown in Table 4. The defective batch percentage is preferably less than 5%. It should be noted that no processing defects were seen on the substrates on the upper surface plate side. Also, in each of the working examples and comparative examples, a total of 201 batches

15 were processed.

A defect can be determined by visually observing the main surface of the glass substrate using a focus lamp and determining whether or not the mirror-finished surface remains. If grinding processing was properly performed using the fixed abrasive particles of the present invention, the substrate surface

20 will appear white and cloudy, and will no longer be a mirror-finished surface. However, if the grinding processing was not performed, that portion will remain a mirror-finished surface and white cloudiness will not be observed.

[0091]

[Table 3]

Table 3	Upper surface plate	Lower surface plate	Processing speed ratio (lower surface plate / upper surface plate)
Working Example 2-1	85% or more, less than 90%	90% or more, less than 95%	1.01
Working Example 2-2	70% or more, less than 80%	80% or more, less than 90%	1.02
Working Example. 2-3	60% or more, less than 70%	70% or more, less than 80%	1.05
Comparative Example 2-1	75% or more, less than 85%	60% or more, less than 70%	0.89

[0092]

[Table 4]

Table 4	Defective batch percentage
Working Example 2-1	0.5% or more, less than 1.5%
Working Example 2-2	less than 0.5%
Working Example 2-3	1% or more, less than 3%
Comparative Example 2-1	5% or more, less than 10%

5 [0093]

The following can be understood from the results shown in Table 3 and Table 4 above.

1. In Working Examples 2-1 to 2-3, in which dressing processing was performed under different conditions on the respective surfaces of the fixed abrasive particle grindstone on the upper surface plate side and the fixed abrasive particle grindstone on the lower surface plate side and removal processing was performed in which the amount of grinding chips removed from the fixed abrasive particle grindstone surface disposed on the lower surface plate side was greater in comparison to that of the fixed abrasive particle grindstone disposed on the upper surface plate side, the difference in processing time between the upper and lower surface plates was reduced as a result, and the frequency with which defects occurred could be reduced significantly, whereby stable processing could be performed in grinding processing using the

fixed abrasive particles. Also, the percentage (%) of effective fixed abrasive particles on the lower surface plate side is more preferable the higher it is. Also, the difference between the upper and lower surface plates is preferably 20% or less, and more preferably 10% or less (Working Example 2-1). Also, if the

5 difference in the effective abrasive particle percentage between the upper and lower surface plates is such that the lower surface plate has an effective abrasive particle percentage that is greater than that of the upper surface plate by 5% or more, balance can be obtained in the processing, and the defective batch percentage improves.

10 2. On the other hand, in Comparative Example 2-1, in which the dressing processing was performed under the same conditions on the respective surfaces of the fixed abrasive particle grindstone on the upper surface plate side and the fixed abrasive particle grindstone on the lower surface plate side, the percentage of the effective fixed abrasive particles on the lower surface plate

15 side, which has a small execution pressure, decreases to be lower than the percentage of the effective fixed abrasive particles on the upper surface plate side, as a result of which the processing balance between the upper and lower surface plates deteriorates and the frequency with which defects occur increases.

20 [0094]

(Manufacture of magnetic disk)

Magnetic disks for perpendicular magnetic recording were obtained by performing the following film formation step on the magnetic-disk glass substrates obtained in the above-described Working Examples 1-1 and 2-1.

25 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 protecting layer, and a lubricant layer are formed in sequence on

the glass substrate. As the protecting layer, a hydrogenated carbon layer was formed. Also, 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
 5 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, was no particular trouble, and good results were obtained.

10 Description of Reference Numerals

[0095]

- | | | |
|----|----|------------------------------|
| | 1 | Diamond pad |
| | 2 | Sheet |
| | 3 | Assembled abrasive particles |
| 15 | 4 | Pellet |
| | 5 | Diamond particle |
| | 10 | Glass substrate |

CLAIMS

1. A method for manufacturing a magnetic-disk glass substrate comprising a plurality of grinding processings for grinding a main surface of a glass substrate by interposing the glass substrate between an upper surface plate and a lower surface plate, each having a grinding surface provided with a fixed abrasive particle grindstone containing an assembled abrasive particle in which a plurality of grinding abrasive particles are bonded via a glass bonding material; and dressing processing performed between a plurality of the grinding processings, wherein

the dressing processing is performed on respective surfaces of the fixed abrasive particle grindstone on the upper surface plate side and the fixed abrasive particle grindstone on the lower surface plate side, thereby adjusting a percentage of the assembled abrasive particles to which sludge is not adhered on the upper and the lower surface plates such that a difference in processing speed between the upper and lower surface plates decreases after the dressing processing than that before the dressing processing.

2. A method for manufacturing a magnetic-disk glass substrate comprising a plurality of grinding processings for grinding a main surface of a glass substrate by interposing the glass substrate between an upper surface plate and a lower surface plate, each having a grinding surface provided with a fixed abrasive particle grindstone containing an assembled abrasive particle in which a plurality of grinding abrasive particles are bonded via a glass bonding material; and dressing processing performed between a plurality of the grinding processings, wherein

the dressing processing is performed under different conditions on respective surfaces of the fixed abrasive particle grindstone on the upper surface plate side and the fixed abrasive particle grindstone on the lower surface

plate side such that a percentage of the assembled abrasive particles to which sludge is not adhered is greater for the lower surface plate.

3. The method for manufacturing a magnetic-disk glass substrate according to claim 1 or 2, wherein a time and/or frequency of the dressing processing is made different between the fixed abrasive particle grindstone on the lower surface plate side and the fixed abrasive particle grindstone on the upper surface plate side.

4. The method for manufacturing a magnetic-disk glass substrate according to any of claims 1 to 3, wherein the dressing processing is performed using a grindstone.

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

6. The method for manufacturing a magnetic-disk glass substrate according to any of claims 1 to 5, wherein the grinding processing is performed on the glass substrate in a state in which the main surface is a mirror-finished surface.

7. The method for manufacturing a magnetic-disk glass substrate according to any one of claims 1 to 6, wherein a percentage of the assembled abrasive particles to which sludge is not adhered is higher by 5% or more in the lower surface plate than that in the upper surface plate.

8. A method for manufacturing a glass substrate as a base of a magnetic-disk glass substrate, comprising a plurality of grinding processings for grinding a main surface of a glass substrate by interposing the glass substrate between an upper surface plate and a lower surface plate, each having a grinding surface provided with a fixed abrasive particle grindstone containing an assembled abrasive particle in which a plurality of grinding abrasive particles are bonded via a glass bonding material; and dressing processing performed

between a plurality of the grinding processings, wherein

the dressing processing is performed on respective surfaces of the fixed abrasive particle grindstone on the upper surface plate side and the fixed abrasive particle grindstone on the lower surface plate side, thereby adjusting a percentage of the assembled abrasive particles to which sludge is not adhered on the upper and the lower surface plates such that a difference in processing speed between the upper and lower surface plates decreases after the dressing processing than that before the dressing processing.

9. A method for manufacturing a glass substrate as a base of a magnetic-disk glass substrate comprising a plurality of grinding processings for grinding a main surface of a glass substrate by interposing the glass substrate between an upper surface plate and a lower surface plate, each having a grinding surface provided with a fixed abrasive particle grindstone containing an assembled abrasive particle in which a plurality of grinding abrasive particles are bonded via a glass bonding material; and dressing processing performed between a plurality of the grinding processings, wherein

dressing processing is performed under different conditions on respective surfaces of the fixed abrasive particle grindstone on the upper surface plate side and the fixed abrasive particle grindstone on the lower surface plate side such that a percentage of the assembled abrasive particles to which sludge is not adhered is greater for the lower surface plate.

10. The method for manufacturing a glass substrate as a base of a magnetic-disk glass substrate according to claim 8 or 9, wherein the grinding processing is performed on the glass substrate in a state in which the main surface is a mirror-finished surface.

11. The method for manufacturing a glass substrate as a base of a magnetic-disk glass substrate according to any one of claims 8 to 10, wherein a percentage of the assembled abrasive particles to which sludge is not adhered is

greater by 5% or more in the lower surface plate than that in the upper surface plate.

12. A method for manufacturing a magnetic-disk glass substrate, wherein polishing processing is at least performed on the main surface of the glass substrate as a base of a magnetic-disk glass substrate that is manufactured by the method of manufacturing a glass substrate as a base of a magnetic-disk glass substrate according to any one of claims 8 to 11.

13. A method for manufacturing a magnetic disk, wherein at least forming a magnetic recording layer is formed on a magnetic-disk glass substrate manufactured using the method for manufacturing a magnetic-disk glass substrate according to any of claims 1 to 7 and 12.