

DESCRIPTION

Title of Invention

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

Technical Field

[0001]

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

Background Art

[0002]

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

[0003]

As described above, it is essential for a magnetic disk to have a highly
smooth surface to achieve the low flying height that is necessary for achieving a

high recording density. In order to attain a highly smooth magnetic disk surface, a highly smooth substrate surface is ultimately required, and thus it is necessary to precisely polish the surface of the glass substrate. In order to produce such a glass substrate, an extremely highly smooth main surface has been achieved by performing grinding (lapping) to adjust the thickness and to reduce the flatness (planeness), and by then further performing polishing to reduce surface roughness and minute waviness.

[0004]

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

[0005]

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

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

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

Prior Art Document

Patent Document

[0006]

- 15 Patent Document 1: JP 2001-6161A
 Patent Document 2: JP 2012-99173A
 Patent Document 3: JP 2009-99249A

Summary of Invention

20 Problem to be Solved by the Invention

[0007]

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

In the case where a glass substrate obtained by cutting a sheet of glass plate manufactured by a float method or the like into a predetermined shape is directly ground with fixed abrasive particles using a conventional diamond pad as

disclosed in Patent Literature 2 above, there is a problem in that diamond abrasive particles have difficulty engaging the substrate surface and tend to slide over the surface due to the glass substrate surface being a so-called mirror surface, thus resulting in a period of time during which no grinding is performed at the early stage of the processing. This greatly reduces productivity.

[0008]

It should be noted that although Patent Literature 3 above discloses a technology for roughening (e.g., lapping using loose abrasive particles made of alumina or the like), by a mechanical or chemical method, the surface of a mirror glass sheet to an extent that the polishing action of fixed abrasive particles will be effective, before the grinding step is performed on a mirror glass sheet using fixed abrasive particles, productivity is reduced due to the addition of another process. Furthermore, although lapping using loose abrasive particles enables stable processing on a mirror glass sheet, deep cuts are formed (deep layers are affected), and therefore, there is a problem in that a processing load on subsequent steps increases.

[0009]

The present invention was made in order to solve the foregoing conventional problems, and an object of the present invention is to provide a method for manufacturing a magnetic-disk glass substrate that can reduce the period of time during which no grinding is performed in a grinding process using fixed abrasive particles, enables grinding to be performed without reducing the processing speed, and can manufacture a high-quality glass substrate at low cost, and a method for manufacturing a magnetic disk using the glass substrate obtained by the above method.

Means for Solving the Problem

[0010]

In order to solve the foregoing problems, the present invention has the

following aspects.

(Aspect 1)

An aspect of the present invention is a method for manufacturing a magnetic-disk glass substrate including grinding processing for grinding a main surface of a glass substrate using a lubricant and a surface plate having a grinding surface provided with fixed abrasive particles including diamond particles, wherein the main surface of the glass substrate is a mirror surface, the grinding processing has a first stage in which the surface of the glass substrate is roughened with a higher load than a load applied in grinding and a second stage in which the surface of the glass substrate is ground with a lower load than the load applied in the first stage, after the first stage, and the grinding processing having the first stage and the second stage is performed using a same device.

[0011]

(Aspect 2)

In the method for manufacturing a magnetic-disk glass substrate according to aspect 1, $P1/P2$ is 3.0 or less, where $P1$ (g/cm^2) is a load applied in the first stage and $P2$ (g/cm^2) is a load applied in the second stage.

(Aspect 3)

In the method for manufacturing a magnetic-disk glass substrate according to aspect 2, $t1 < t2$, where $t1$ is a period of time the load $P1$ is maintained in the first stage and $t2$ is a period of time the load $P2$ is maintained in the second stage.

[0012]

(Aspect 4)

In the method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 3, a surface roughness of the main surface of the glass substrate to be ground is $0.05 \mu\text{m}$ or less in Ra.

[0013]

(Aspect 5)

In the method for manufacturing a magnetic-disk glass substrate according

to any of aspects 1 to 4, a processing speed in the grinding processing is 3.0 to 9.0 $\mu\text{m}/\text{minute}$.

(Aspect 6)

5 In the method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 5, a surface roughness of the glass substrate after the second stage is 0.080 to 0.130 μm in Ra.

[0014]

(Aspect 7)

10 Another aspect of the present invention is a method for manufacturing a magnetic disk in which at least a magnetic layer is formed on the magnetic-disk glass substrate manufactured by the method for manufacturing a magnetic-disk glass substrate according to any of aspects 1 to 6.

Advantageous Effects of the Invention

15 [0015]

With the present invention, it is possible to suppress a reduction of productivity caused by the occurrence of a period of time during which no grinding is performed in a grinding process using conventional fixed abrasive particles. Moreover, with the present invention, it is possible to suppress the roughness of a
20 processed surface to a low level without reducing the processing speed, and to reduce the processing load in subsequent steps. This makes it possible to manufacture a high-quality glass substrate at low cost. Furthermore, it is possible to obtain a highly reliable magnetic disk using the glass substrate obtained thereby.

25 Brief Description of Drawings

[0016]

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

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

FIG. 3 is a diagram showing an example of a sequence of applied loads in grinding processing of the present invention.

FIG. 4 is a schematic cross-sectional view showing a configuration of a diamond pad that is used in the present invention.

5

Mode for Embodying the Invention

[0017]

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

10

As described in aspect 1 above, the present invention is a method for manufacturing a magnetic-disk glass substrate including grinding processing for grinding a main surface of a glass substrate using a lubricant and a surface plate having a grinding surface provided with fixed abrasive particles including diamond particles, wherein the main surface of the glass substrate is a mirror surface, the grinding processing has a first stage in which the surface of the glass substrate is roughened with a higher load than a load applied in grinding and a second stage in which the surface of the glass substrate is ground with a lower load than the load applied in the first stage, after the first stage, and the grinding processing having the first stage and the second stage is performed using a same device.

15

20 [0018]

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

25

In a method for manufacturing a magnetic-disk glass substrate according to the present invention, a glass substrate whose main surface is a mirror surface is obtained by cutting a sheet of glass plate that has been manufactured by a float method or a down draw method into a glass substrate having a predetermined size. Alternatively, a glass substrate that is manufactured by pressing molten glass and

whose main surface is a mirror surface may also be used.

[0019]

Next, grinding (lapping) for enhancing the dimensional accuracy and shape accuracy is performed on this glass substrate. In this grinding, a double-side lapping device is generally used to grind the main surfaces of the glass substrate with hard abrasive particles such as diamond particles. By grinding the main surfaces of the glass substrate in this manner, the glass substrate is processed so as to have a predetermined thickness and flatness and to attain a predetermined surface roughness.

10 [0020]

The present invention relates to an improvement of this grinding. The grinding processing in the present invention is grinding that uses fixed abrasive particles containing diamond particles, and for example, in a double-side lapping device, a glass substrate that is held by a carrier is tightly placed between upper and lower surface plates to which diamond pads serving as a grinding tool (grindstone with fixed abrasive particles) are attached, 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 promote processing.

[0021]

FIG. 4 shows an outline of the configuration of a diamond pad 1 serving as a grinding tool (grindstone with fixed abrasive particles) used in the present invention, and the diamond pad 1 is a sheet to which aggregates 3 consisting of some diamond particles 5 (see FIG. 2) held together with a binder such as glass, ceramic, a metal or a resin are fixed by using a supporting material 6 such as a resin (e.g., acrylic resin). Also, FIG. 1 shows an outline of another configuration in which the diamond pad 1 is obtained by sticking, to a sheet 2, pellets 4 formed by

using a supporting material such as a resin (e.g., acrylic resin) to fix aggregates 3 consisting of some diamond particles 5 (see FIG. 2) held together with a binder such as glass, ceramic, a metal or a resin. It should be understood that the configurations shown in FIGS. 1 and 4 are merely examples, and the present invention is not to be construed as being limited thereto. For example, a diamond pad obtained by forming a resin layer containing the above-described aggregates 3 on a sheet and then forming grooves in the resin layer to form projections may also be used.

[0022]

10 It is possible to manufacture diamond pads with different particle diameters (average particle diameters) of the above-described aggregates 3 and different densities of the abrasive particles in the resin.

It should be noted that in this embodiment, a case where the above-described aggregates are used as diamond fixed abrasive particles is described. Accordingly, in the present invention, unless otherwise stated, "diamond fixed abrasive particles" means the above-described aggregates, and the terms "average particle diameter of diamond fixed abrasive particles" and "density of abrasive particles" respectively mean an average particle diameter of the above-described aggregates and the density of the above-described aggregates in the resin.

20 However, the present invention is not limited to the case where the above-described aggregates are used as diamond fixed abrasive particles. It is also possible to use a diamond pad in which each of diamond fixed abrasive particles is not an aggregate but a single diamond particle.

25 [0023]

As described above, the grinding processing of the present invention has a first stage in which the surface of the glass substrate is roughened with a higher load than a load applied in grinding and a second stage in which the surface of the glass substrate is ground with a lower load than the load applied in the first stage,

after the first stage, and the grinding processing having the first stage and the second stage is performed using a same device.

[0024]

In order to directly grind the mirror glass surface using a diamond pad, first,
5 it is necessary to apply a higher load to the glass surface than that in ordinary grinding for the purpose of causing the diamond abrasive particles to engage the surface of the glass substrate. A high load enables the roughness of the glass surface to be increased (roughened) because the cuts made by the abrasive particles are deeper. The above-described first stage is a stage for causing the
10 diamond abrasive particles to engage a mirror glass surface to roughen the surface in this manner.

[0025]

After the glass surface is roughened in the first stage during such processing, a high load is no longer necessary in the grinding. The load is thus
15 reduced, and original grinding (main processing) is performed under conditions that cause the cuts made by the abrasive particles to be shallower. The above-described second stage is a stage for performing this main processing. FIG. 2 is a schematic view illustrating a state during grinding, and shows a state in which the aggregates 3 used as diamond fixed abrasive particles are engaging a
20 glass substrate 10 and grind the glass substrate 10 (expected view).

[0026]

By performing the grinding process including the first stage and the second stage described above, it is possible to perform the grinding without reducing the processing speed. Furthermore, by adjusting detailed conditions of the grinding,
25 the roughness of the finished surface can also be suppressed to a low level.

FIG. 3 is a diagram showing an example of a sequence of applied loads in the grinding processing of the present invention.

In FIG. 3, the horizontal axis indicates time, and the vertical axis indicates load. The load is gradually increased from the start to a point of time when the

load reaches P1 (point A), and is then maintained for a given fixed time period (t1). This is the above-described first stage, in which the glass surface is roughened.

It should be noted that the application of load reaching point A may be divided into multiple steps. That is, the load may be increased in a stepwise manner (in a stepped manner in the sequence diagram).

[0027]

The load is gradually reduced from point B to a point of time when the load reaches an ordinary grinding load P2 (point C), and is then maintained for a given fixed time period (t2). The grinding is finished at point D. The stage between point C and point D is the above-described second stage, in which the main processing is performed.

It should be noted that the terms "load P1" and "load P2" in this case indicate values that are maintained for a given fixed time period, and do not include a load that is increasing, and the like.

15 [0028]

It is preferable that the load P1 in the above-described first stage is in a range of 130 to 200 g/cm². If the load P1 is smaller than 130 g/cm², the glass surface will be insufficiently roughened. Therefore, the period of time during which no grinding is performed cannot be reduced sufficiently, and there is a risk that the processing speed will decrease. That is, since the surface roughness after the first stage will be insufficiently increased, the fixed abrasive particles will also slide over the surface in the second stage, and there is a risk that the processing rate will decrease. Also, if the load P1 is smaller than 130 g/cm², the adhesiveness between the glass substrate and the surface plates may be insufficient. In this case, the difference between the load applied to the upper surface of the glass substrate by the upper surface plate and the load applied to the lower surface of the glass substrate by the lower surface plate increases, and there may be a problem in that all or part of the lower surface of the glass substrate may not be ground. It is inferred that this is because coolant is likely to accumulate on

the lower surface plate due to gravity, and therefore, a film of the coolant is formed between the lower surface plate and the glass substrate. This problem can be solved by firmly sandwiching the glass substrate using the upper and lower surface plates while applying a load higher than 130 g/cm^2 .

5 On the other hand, if the load P_1 is larger than 200 g/cm^2 , cuts made by the abrasive particles are formed too deeply, and thus a large number of scratches occur. Therefore, it is necessary to increase machining allowance in the main processing and the subsequent polishing step, and there is a risk that the processing time will be extended. In addition, the glass substrate may be broken
10 or cracked.

[0029]

It is preferable that the load P_2 in the above-described second stage is in a range of 50 to 120 g/cm^2 . By grinding the roughened surface with a load that is lower than that in the first stage and that is in the above-described range, the
15 roughness of the processed surface can be suppressed to a low level.

Furthermore, it is preferable that P_1/P_2 is 1.20 or more. This makes it possible to increase the processing speed and reduce the roughness. More specifically, the surface roughness after the grinding can be reduced to $0.12 \text{ }\mu\text{m}$ or less.

20 Also, it is preferable that P_1/P_2 is 3.0 or less. If P_1/P_2 is greater than 3.0 , the adhesiveness between the glass substrate and the surface plates is temporarily insufficient when the processing moves from the first stage to the second stage, and thus there may be a problem in that all or part of the lower surface of the glass substrate may not be ground.

25 [0030]

It is preferable that the load application speed (slope k) in the first stage between the start of processing and point A above (load P_1) is 0.5 to $15 \text{ g/(cm}^2\cdot\text{sec)}$. The slope k is preferably not smaller than $0.5 \text{ g/(cm}^2\cdot\text{sec)}$ (that is, the application speed is low) because the abrasive particles slide rather than engaging

because of the low load and are instead abraded, such that the grinding capacity is deteriorated due to factors such as insufficient roughening in the first stage and a reduced processing rate. On the other hand, in the case where the slope k is greater than $15 \text{ g}/(\text{cm}^2 \cdot \text{sec})$ (that is, the application speed is high), a sudden load is applied to the glass substrate, and therefore, there is a risk that the grinding capacity will be deteriorated due to the abrasive particles being crushed and the glass substrate will break. Furthermore, it is more preferable that the slope k is $4 \text{ g}/(\text{cm}^2 \cdot \text{sec})$ or more from the viewpoint of the number of times (life) the grinding pads can be used.

10 [0031]

It is preferable that the time period t_1 for roughening the surface with the load P_1 in the above-described first stage is in a range of 10 to 600 seconds. If t_1 is shorter than 10 seconds, there is a risk that the abrasive particles will insufficiently engage the glass main surface and the processing speed will decrease. On the other hand, if t_1 is longer than 600 seconds, deep scratches are likely to occur, and there is a risk that the finished main surface will be rough.

[0032]

It is preferable that a period of time between point B and point C during which the load is gradually reduced from the load P_1 to the ordinary grinding load P_2 is in a range of 10 to 90 seconds, for example. If the period of time between points B and C is shorter than 10 seconds, there is a risk that the flatness will be deteriorated due to the abrupt change of load. In such a case, it is thought that the difference between the load applied to the upper surface of the glass substrate by the upper surface plate and the load applied to the lower surface of the glass substrate by the lower surface plate temporarily increases due to the same mechanism as that in the above-described case where the load P_1 is smaller than $130 \text{ g}/\text{cm}^2$. Therefore, it is inferred that portions having a poor flatness will remain because all or part of the glass substrate has not been properly ground.

On the other hand, if the period of time between points B and C is longer

than 90 seconds, there are risks that it will become difficult to control the thickness because of the glass substrate being excessively ground while the load changes from P1 (first stage) to P2 (second stage), and that deep scratches will occur to increase the roughness of the finished main surface.

5 [0033]

It is preferable that the time period t_2 during which the grinding is performed with the load P2 in the above-described second stage is 30 seconds or more. If a certain amount of grinding is not performed with the load P2, there is a risk that grooves formed with the load P1 will not be completely removed and will
10 remain as scratches. The upper limit of t_2 is determined as appropriate considering finish quality to be achieved by the grinding processing, and the like.

It should be noted that it is preferable that $t_1 < t_2$ because the finished roughness can be reduced. If $t_1 \geq t_2$, the surface roughness after the processing may not be reduced. That is, the present invention is a technology capable of
15 achieving both a high grinding rate and a low roughness after processing, but if the period of time during which grinding is performed with a low load in the second stage is insufficient, the roughness formed in the first stage may be insufficiently reduced in the second stage. In addition, there is a risk that scratches will remain. These problems can be solved by an increase in machining allowance in the
20 subsequent polishing step, which may cause an increase in manufacturing cost.

Moreover, it is preferable that $P_1 \times t_1$ (area) $< P_2 \times t_2$ (area). This makes it possible for the surface roughness after the grinding to be sufficiently reduced.

[0034]

In the present invention, the processing speed of the overall grinding
25 processing is preferably $2.0 \mu\text{m}/\text{minute}$ or more, and more preferably $3.0 \mu\text{m}/\text{minute}$ or more. If the processing speed is in this range, the grinding can be performed without reducing the processing speed. It should be noted that the processing speed of the overall grinding processing refers to a value obtained by dividing the total ground thickness by the total processing time (including the first

stage and the second stage).

[0035]

In the present invention, it is preferable that the average particle diameter of the above-described diamond fixed abrasive particles is 20 to 40 μm .

5 Furthermore, it is preferable that the particle diameter of each diamond fixed abrasive particle is 10 to 50 μm . If the average particle diameter of the above-described diamond abrasive particles or the particle diameter of each diamond abrasive particle is smaller than the above-described values, shallow cuts are made in the mirror glass substrate, and the abrasive particles do not engage
10 the glass substrate. On the other hand, if the average particle diameter of the above-described diamond abrasive particles or the particle diameter of each diamond abrasive particle is larger than the above-described values, the finished roughness increases, and therefore, the machining allowance load in subsequent steps increases.

15 It should be noted that as described above, "diamond fixed abrasive particles" here means the above-described aggregates. Moreover, it is preferable that each diamond particle contained in the aggregates has a size of 1 to 5 μm in average particle diameter.

[0036]

20 It should be noted that in the present invention, the above-described average particle diameter (D50) denotes a particle diameter at which a cumulative 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
25 (50% diameter)" hereinafter). In the present invention, specifically, the cumulative average particle diameter is a value obtained by measuring the particle diameter using, for example, a particle diameter/particle size distribution measurement device.

[0037]

As described above, in the present invention, the grinding is performed using the same grindstone with fixed abrasive particles (diamond pad), and "processing with a higher load than that in ordinary grinding and processing with an ordinary load" are continuously performed in one process. The substrate is
5 replaced and the same process is repeated in order to increase the productivity. It was found that at this time, sludge is likely to accumulate on the surface of the grindstone with fixed abrasive particles due to the main surface of the substrate that is processed being a mirror surface. In the case where glass substrates are processed after conventional lapping, the surface roughness of a substrate to be
10 processed is large, and therefore, sludge accumulated on the grindstone surface is removed by the surface of new glass substrates that are processed one after another. However, such an effect is not obtained in the case where mirror glass substrates are directly ground as in the present invention.

That is, it was found that it is necessary to precisely control the amount of
15 projection of abrasive particles in the case where processing is performed a large number of times using the same grindstone with fixed abrasive particles in order to increase the productivity.

[0038]

In the grinding of the present invention, it is preferable to grind the main
20 surface of the glass substrate using a grindstone in which the amount of projection of abrasive particles (that is, diamond fixed abrasive particles) is favorably adjusted.

[0039]

If a grindstone in which the amount of projection of the above-described
25 abrasive particles is low is used, for example, the abrasive particles are inhibited from coming into contact with the glass surface due to sludge accumulated on the grindstone surface, and a large number of abrasive particles cannot sufficiently act on the glass surface (i.e., the action on the glass surface is weak). Therefore, the above-described local grinding failure occurs, as a result of which the rate of

occurrence of post-processing flatness failure increases.

[0040]

In contrast, when a grindstone in which the amount of projection of abrasive particles is favorably adjusted is used, even if sludge is accumulated on the grindstone surface, it is possible to suppress a situation where the abrasive particles are inhibited from coming into contact with the glass surface. Therefore, the abrasive particles stably act on the glass surface, thus making it possible to perform stable grinding without uneven grinding.

[0041]

10 The above-described amount of projection of abrasive particles in the grindstone can be measured as follows.

In grindstones (generally formed in a disk shape) of the upper and lower surface plates before performing the grinding, six samples (pad pieces) in total that each have a size of 2.5 mm×2.5 mm are cut out at the positions 10%, 50% and 15 90% away from the inner circumference when the distance between the inner circumference and the outer circumference is given as 100%. In each of the six samples, five arbitrary abrasive particles are selected from an observation image obtained using a laser microscope, for example, the differences in height between the selected abrasive particles and resin portions around the abrasive particles are 20 measured, and the amount of projection of the abrasive particles in the grindstone is defined as the average value of the differences in height of all of the selected abrasive particles.

[0042]

The amount of projection of abrasive particles can be adjusted by dressing, 25 for example. Specifically, the double-side grinding device used in grinding is also used in dressing, for example, and dressing can be performed in a state in which grindstones that are controlled so as to have appropriate thickness variation are brought into contact with the surfaces of a grindstone such as a diamond pad provided on the upper and lower surface plates, and the upper and lower surface

plates of the double-side grinding device are rotated. Although there is no particular restriction on the material of a grindstone used in dressing, it is preferable to use an alumina grindstone, for example. In this case, a plurality of grindstones having different thickness variations may also be used to perform dressing in a gradual manner.

[0043]

In the present invention, the main surface of the glass substrate subjected to grinding processing is a mirror surface, and the surface roughness is generally 0.05 μm or less in Ra, and more preferably 0.001 to 0.01 μm . In the present invention, in particular, a glass sheet in which the surface roughness Ra is 0.001 to 0.01 μm , which is extremely low, can be used as the glass substrate to be subjected to grinding, and therefore, machining allowance in subsequent steps can be suppressed to a minimum level, thus making it possible to manufacture a low-cost magnetic disk glass substrate.

Moreover, in the present invention, the surface roughness of the glass substrate after the above-described first stage is in a range of about 0.100 to 0.150 μm in Ra. By roughening the surface such that the surface roughness is in this range, the grinding in the subsequent second stage is favorably performed.

Furthermore, in the present invention, the surface of the glass substrate after the above-described second stage is finished so as to have a roughness in a range of 0.080 to 0.130 μm in Ra. The finished roughness can be suppressed to a low level in this manner, thus making it possible to reduce the processing load in subsequent steps.

[0044]

As described above, in the grinding processing of the present invention, it is possible to suppress a reduction of productivity caused by a period of time during which no grinding is performed in grinding using conventional fixed abrasive particles, and the grinding processing having the first stage and the second stage can be continuously performed using the same device, thus making it possible to

increase the productivity. Moreover, with the grinding processing of the present invention, it is possible to suppress the roughness of a processed surface to a low level without reducing the processing speed, and to reduce the processing load in subsequent steps.

5 [0045]

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. A preferable example of such

10 aluminosilicate glass is glass that contains SiO_2 as a main component and Al_2O_3 in an amount of 20 wt% or less. Furthermore, glass that contains SiO_2 as a main component and Al_2O_3 in an amount of 15 wt% or less is more preferable.

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

20 Also, as this aluminosilicate glass, it is possible to use glass for chemical strengthening that has a composition of SiO_2 in an amount of 58 to 66 wt%, Al_2O_3 in an amount of 13 to 19 wt%, Li_2O in an amount of 3 to 4.5 wt%, Na_2O in an amount of 6 to 13 wt%, K_2O in an amount of 0 to 5 wt%, R_2O (where $\text{R}_2\text{O}=\text{Li}_2\text{O}+\text{Na}_2\text{O}+\text{K}_2\text{O}$) in an amount of 10 to 18 wt%, MgO in an amount of 0 to 3.5 wt%, CaO in an
25 amount of 1 to 7 wt%, SrO in an amount of 0 to 2 wt%, BaO in an amount of 0 to 2 wt%, RO (where $\text{RO}=\text{MgO}+\text{CaO}+\text{SrO}+\text{BaO}$) in an amount of 2 to 10 wt%, TiO_2 in an amount of 0 to 2 wt%, CeO_2 in an amount of 0 to 2 wt%, Fe_2O_3 in an amount of 0 to 2 wt%, and MnO in an amount of 0 to 1 wt% (where $\text{TiO}_2+\text{CeO}_2+\text{Fe}_2\text{O}_3+\text{MnO}=0.01$ to 3 wt%).

[0046]

As heat resistant glass, it is preferable to use, for example, glass that contains SiO_2 in an amount of 50 to 75 mol%, Al_2O_3 in an amount of 0 to 5 mol%, BaO in an amount of 0 to 2 mol%, Li_2O in an amount of 0 to 3 mol%, ZnO in an amount of 0 to 5 mol%; Na_2O and K_2O in a total amount of 3 to 15 mol%, MgO , CaO , SrO and BaO in a total amount of 14 to 35 mol%, and ZrO_2 , TiO_2 , La_2O_3 , Y_2O_3 , Yb_2O_3 , Ta_2O_5 , Nb_2O_5 and HfO_2 in a total amount of 2 to 9 mol%, and that 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.

10 The glass may also contain SiO_2 in an amount of 56 to 75 mol%, Al_2O_3 in an amount of 1 to 9 mol%, alkali metal oxide(s) selected from the group consisting of Li_2O , Na_2O , and K_2O in a total amount of 6 to 15 mol%, alkaline earth metal oxide(s) selected from the group consisting of MgO , CaO , and SrO in a total amount of 10 to 30 mol%, and oxide(s) selected from the group consisting of 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, it is preferable that the Al_2O_3 content in the glass composition is 15 wt% or less. Furthermore, it is more preferable that the Al_2O_3 content is 5 mol% or less.

20 [0047]

It should be noted that a conventional grinding step is generally performed through two stages that are a rough grinding step (first grinding step) and a precision grinding step (second grinding step), but use of the grinding processing according to the present invention makes it possible to perform grinding in one step.

[0048]

After this grinding, mirror-polishing is performed to obtain a high precision flat surface. In the present invention, the roughness of the processed surface can be reduced in this grinding by applying the method using fixed abrasive particles

according to the present invention instead of a conventional method using loose abrasive particles, and therefore, the amount of glass to be removed in the subsequent mirror-polishing step is small, the processing load is reduced, and the processing cost can be reduced.

5 [0049]

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

[0050]

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

20 From a practical viewpoint, the surface roughness (maximum roughness Rmax and arithmetic average roughness Ra, for example) in the present invention is preferably the surface roughness of a surface shape obtained by measuring a square area of 5 μm ×5 μm using an atomic force microscope (AFM). It should be noted that the measurement may also be performed using a stylus type surface
25 roughness tester.

[0051]

In the present invention, it is preferable to perform chemical strengthening after the first polishing and before the second polishing. As a method for the chemical strengthening, it is preferable to use, for example, a low-temperature

ion-exchange method that performs ion exchange in a temperature range not exceeding the glass transition point. The chemical strengthening is processing in which the glass substrate is brought in contact with a molten chemical strengthening salt so that an alkali metal element having a relatively large atomic radius in the chemical strengthening salt and an alkali metal element having a relatively small atomic radius in the glass substrate are ion-exchanged, and thus the alkali metal element having a relatively large atomic radius permeates through the surface layer of the glass substrate, and compressive stress is generated on the surface of the glass substrate. A glass substrate that has undergone the chemical strengthening has excellent impact resistance, and therefore, it is particularly preferable to mount the glass substrate in an HDD for mobile use, for example. An alkali metal nitrate such as potassium nitrate or sodium nitrate can be preferably used as the chemical strengthening salt.

[0052]

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 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. Interposing a base layer between the glass substrate and the magnetic layer makes it possible to control the orientation direction and size of magnetic particles in the magnetic layer. For example, use of a cubic-system base layer made of Cr-based alloy or the like makes it possible to orient, for example, the direction of easy magnetization of the magnetic layer along the magnetic disk surface. In this case, the magnetic disk of a longitudinal magnetic recording type is manufactured. In addition, for example, use of a hexagonal-system base layer containing Ru and Ti makes it possible to

orient, for example, the direction of easy magnetization of the magnetic layer along the normal of the plane of the magnetic disk. In this case, the magnetic disk of a perpendicular magnetic recording type is manufactured. The base layer can be formed by a sputtering method in the same manner as the magnetic layer.

5 [0053]

It is preferable to form a protective layer and a lubricant layer in this order on the magnetic layer. An amorphous hydrogenated carbon-based protecting layer is preferable as the protective layer. The protective layer can be formed by a plasma CVD method, for example. As the lubricant layer, a lubricant that has a functional group at the terminal of the main chain of a perfluoropolyether compound can be used. In particular, it is preferable that the lubricant contains, as a main component, a perfluoropolyether compound that has a hydroxyl group as a polar functional group at the terminal. The lubricant layer can be coated and formed by a dipping method.

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

Examples

[0054]

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

(Example 1)

A magnetic disk glass substrate of this example was manufactured through (1) a substrate preparation step, (2) a shape processing step, (3) an end surface polishing step, (4) main surface grinding processing, (5) a main surface polishing step (first polishing step), (6) a chemical strengthening step, and (7) a main surface polishing step (second polishing step) as described below.

[0055]

(1) Substrate preparation step

A large glass sheet constituted by aluminosilicate glass having a thickness of 1 mm manufactured by a float method was prepared, and was cut into small square pieces using a diamond cutter. Next, each of the glass pieces was
 5 processed into a disk shape that had an outer diameter of 65 mm and a circular hole having an inner diameter of 20 mm in the center portion using a diamond cutter. As this aluminosilicate glass, glass for chemical strengthening was used that had a composition of SiO_2 in an amount of 58 to 66 wt%, Al_2O_3 in an amount of 13 to 19 wt%, Li_2O in an amount of 3 to 4.5 wt%, Na_2O in an amount of 6 to 13 wt%,
 10 K_2O in an amount of 0 to 5 wt%, R_2O (where $\text{R}_2\text{O}=\text{Li}_2\text{O}+\text{Na}_2\text{O}+\text{K}_2\text{O}$) in an amount of 10 to 18 wt%, MgO in an amount of 0 to 3.5 wt%, CaO in an amount of 1 to 7 wt%, SrO in an amount of 0 to 2 wt%, BaO in an amount of 0 to 2 wt%, RO (where $\text{RO}=\text{MgO}+\text{CaO}+\text{SrO}+\text{BaO}$) in an amount of 2 to 10 wt%, TiO_2 in an amount of 0 to 2 wt%, CeO_2 in an amount of 0 to 2 wt%, Fe_2O_3 in an amount of 0 to 2 wt%, and
 15 MnO in an amount of 0 to 1 wt% (where $\text{TiO}_2+\text{CeO}_2+\text{Fe}_2\text{O}_3+\text{MnO}=0.01$ to 3 wt%).
 [0056]

(2) Shape processing step

Next, predetermined chamfering was performed on an outer circumferential end surface and an inner circumferential end surface. It should be noted that a
 20 magnetic disk having an outer diameter of 65 mm is generally used in a 2.5-inch HDD (hard disk drive).
 [0057]

(3) End surface polishing step

Next, the end surfaces (inner and outer circumferential end surfaces) of the
 25 glass substrate were polished by a known brushing method while the glass substrate was rotated.
 [0058]

(4) Main surface grinding processing

This main surface grinding processing was performed using a double-side

lapping device in which the glass substrate held by a carrier was set between the upper and lower surface plates to which diamond pads were attached. A grindstone with fixed abrasive particles was used as the diamond pads, the fixed abrasive particles being obtained by fixing, using a resin, aggregates in which a plurality of diamond particles were bound by being vitrified with glass. Here, the average particle diameter of the aggregates was set to about 25 μm , and the average particle diameter (D50) of each diamond particle in the aggregates was set to 2.5 μm . This processing was performed using a lubricant. It should be noted that the main surface of the glass substrate before the grinding processing was a mirror surface. The roughness of the main surface measured using a stylus type roughness tester was 5 nm in Ra.

[0059]

Specifically, the rotation rate of the surface plates was selected as appropriate in a range of 10 to 100 rpm, and a load was applied to the glass substrate in accordance with the sequence shown in FIG. 3. In this example, the load (P1) in the first stage (roughening) and the load (P2) in the second stage (main processing) were respectively set to 150 g/cm^2 and 100 g/cm^2 , and both surfaces of the glass substrates accommodated in a carrier were processed by rotating a sun gear and an internal gear of the above-described lapping device.

It should be noted that in FIG. 3, the slope k was set to 10 $\text{g}/(\text{cm}^2 \cdot \text{sec})$, t_1 was set to 60 seconds, the period of time between points B and C was set to 15 seconds, and t_2 was set to 200 seconds, which was longer than t_1 .

Ultrasonic cleaning was performed on the glass substrate after the above-described grinding processing while the glass substrate was sequentially immersed in respective cleaning baths (to which ultrasonic waves were applied) of a neutral detergent and water.

[0060]

In this grinding processing, fifty glass substrates per processing (one batch) were processed. The surface roughness of each glass substrate after the

processing was measured using a stylus type surface roughness tester. Tables 1 and 2 show the measurement results for surface roughness (Ra) and processing speed of the overall grinding processing. It should be noted that the above-described processing speed of the overall grinding processing is a value obtained by dividing the total ground thickness by the total processing time (including the first stage and the second stage). Moreover, evaluation of scratches was performed by counting the number of glass substrates in which scratches occurred on the main surface using a light-condensing lamp in a dark room.

10 [0061]

(5) Main surface polishing step (first polishing step)

Next, a first polishing step to remove blemishes and distortion remaining after the above-described grinding was performed using a double-side polishing device. In the double-side polishing device, a glass substrate that is held by a carrier is tightly placed between the upper and lower 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 substrate revolves while rotating on the surface plates so that both main surfaces of the glass substrate are polished simultaneously. Specifically, the first polishing step was performed using a hard polisher (hard urethane foam) as a polisher. A polishing liquid obtained by dispersing cerium oxide as an abrasive in water was used.

25 [0062]

(6) Chemical strengthening step

Next, chemical strengthening was performed on the glass substrate that had undergone the above-described cleaning. Chemical strengthening was performed by preparing a chemical strengthening liquid obtained by mixing and

melting potassium nitrate and sodium nitrate, and immersing the glass substrate in the chemical strengthening liquid.

[0063]

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

5 Next, a second polishing step was performed using the same double-side polishing device as used in the above-described first polishing step, but polishing pads with a soft polisher (suede) were used. This second polishing step is mirror-polishing processing to finish surfaces into smooth mirror surfaces by further reducing the surface roughness while maintaining the flat surfaces obtained in the
10 first polishing step described above. A polishing liquid obtained by dispersing colloidal silica in water was used. The glass substrate after the second polishing step was cleaned as appropriate and dried.

[0064]

 Moreover, the surface roughness of the main surfaces of the glass
15 substrate obtained through the above-described steps was measured using an atomic force microscope (AFM), revealing that a glass substrate with an ultra-smooth surface of 1.53 nm in Rmax and 0.13 nm in Ra was obtained. In addition, when the glass substrate surfaces were analyzed using an atomic force microscope (AFM) and an electron microscope, the glass substrate had mirror
20 surfaces and no surface defects such as projections or blemishes were observed.

 The resulting glass substrate had an outer diameter of 65 mm, an inner diameter of 20 mm, and a thickness of 0.635 mm.

 In this manner, the magnetic-disk glass substrate of this example was obtained.

25 [0065]

(Example 2)

 The grinding processing in example 1 was performed in the same manner as in example 1, except that the load (P1) in the first stage (roughening) was set to 130 g/cm². A magnetic-disk glass substrate was obtained by performing the steps

other than the grinding processing in the same manner as in example 1.

Table 1 shows the measurement results for scratches on the ground surface and processing speed of the total grinding processing regarding the glass substrate after the grinding.

5 [0066]

(Example 3)

The grinding processing in example 1 was performed in the same manner as in example 1, except that the load (P1) in the first stage (roughening) was set to 200 g/cm^2 . A magnetic-disk glass substrate was obtained by performing the steps
10 other than the grinding processing in the same manner as in example 1.

Table 1 shows the measurement results for scratches on the ground surface and processing speed of the total grinding processing regarding the glass substrate after the grinding.

[0067]

15 (Example 4)

The grinding processing in example 1 was performed in the same manner as in example 1, except that the load (P2) in the second stage (main processing) was set to 50 g/cm^2 . A magnetic-disk glass substrate was obtained by performing the steps other than the grinding processing in the same manner as in example 1.

20 Table 2 shows the measurement results for surface roughness (Ra) and processing speed of the total grinding processing that were measured in the same manner as in example 1 regarding the glass substrate after the grinding.

[0068]

(Example 5)

25 The grinding processing in example 1 was performed in the same manner as in example 1, except that the load (P2) in the second stage (main processing) was set to 70 g/cm^2 . A magnetic-disk glass substrate was obtained by performing the steps other than the grinding processing in the same manner as in example 1.

Table 2 shows the measurement results for surface roughness (Ra) and

processing speed of the total grinding processing that were measured in the same manner as in example 1 regarding the glass substrate after the grinding.

[0069]

(Example 6)

5 The grinding processing in example 1 was performed in the same manner as in example 1, except that the load (P2) in the second stage (main processing) was set to 120 g/cm^2 . A magnetic-disk glass substrate was obtained by performing the steps other than the grinding processing in the same manner as in example 1.

10 Table 2 shows the measurement results for surface roughness (Ra) and processing speed of the total grinding processing that were measured in the same manner as in example 1 regarding the glass substrate after the grinding.

[0070]

(Example 7)

15 The grinding processing in example 1 was performed in the same manner as in example 1, except that the load (P1) in the first stage (roughening) was set to 120 g/cm^2 . A magnetic-disk glass substrate was obtained by performing the steps other than the grinding processing in the same manner as in example 1.

20 Table 1 shows the measurement results for scratches on the ground surface and processing speed of the total grinding processing regarding the glass substrate after the grinding.

[0071]

(Example 8)

25 The grinding processing in example 1 was performed in the same manner as in example 1, except that the load (P1) in the first stage (roughening) was set to 210 g/cm^2 . A magnetic-disk glass substrate was obtained by performing the steps other than the grinding processing in the same manner as in example 1.

Table 1 shows the measurement results for scratches in the ground surface and processing speed of the total grinding processing regarding the glass substrate

after the grinding.

[0072]

(Example 9)

The grinding processing in example 1 was performed in the same manner
5 as in example 1, except that the load (P2) in the second stage (main processing)
was set to 40 g/cm². A magnetic-disk glass substrate was obtained by performing
the steps other than the grinding processing in the same manner as in example 1.

Table 2 shows the measurement results for surface roughness (Ra) and
processing speed of the total grinding processing that were measured in the same
10 manner as in example 1 regarding the glass substrate after the grinding.

[0073]

(Example 10)

The grinding processing in example 1 was performed in the same manner
as in example 1, except that the load (P2) in the second stage (main processing)
15 was set to 130 g/cm². A magnetic-disk glass substrate was obtained by
performing the steps other than the grinding processing in the same manner as in
example 1.

Table 2 shows the measurement results for surface roughness (Ra) and
processing speed of the total grinding processing that were measured in the same
20 manner as in example 1 regarding the glass substrate after the grinding.

[0074]

(Comparative example)

In the grinding processing in example 1, the load was set to 100 g/cm², and
the processing began with the grinding processing (main processing). A
25 magnetic-disk glass substrate was obtained by performing the steps other than the
grinding processing in the same manner as in example 1.

Table 1 shows the measurement results for scratches on the ground
surface and processing speed of the total grinding processing regarding the glass
substrate after the grinding.

[0075]

[Table 1]

Table 1	1st stage (roughening) load P1 (g/cm ²)	2nd stage (main processing) load P2 (g/cm ²)	P1/P2	Processing speed (μm/min)	Number of substrates in which scratches occurred
Comparative Example.	none	100	1.00	1.9	0
Example 7	120	100	1.20	2.0	0
Example 2	130	100	1.30	4.8	0
Example 1	150	100	1.50	6.1	0
Example 3	200	100	2.00	8.2	0
Example 8	210	100	2.10	8.5	1

[0076]

5 [Table 2]

Table 2	1st stage (roughening) load P1 (g/cm ²)	2nd stage (main processing) load P2 (g/cm ²)	P1/P2	Processing speed (μm/min)	Ra (μm)
Example 9	150	40	3.75	3.2	0.085
Example 4	150	50	3.00	3.5	0.088
Example 5	150	70	2.14	4.9	0.093
Example 1	150	100	1.50	6.1	0.096
Example 6	150	120	1.25	6.9	0.112
Example 10	150	130	1.15	7.2	0.123

[0077]

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

- 10 1. In the comparative example in which the above-described first stage was not provided, the load was set to the load in the grinding process (main processing), and the processing began with the grinding process (main processing), the period of time during which no grinding was performed became longer, and the processing speed decreased.
- 15 2. In contrast, with the examples of the present invention, it was possible to

reduce the period of time during which no grinding processing was performed in the grinding using conventional fixed abrasive particles, and to perform the grinding without reducing the processing speed. Furthermore, it was also possible to suppress the roughness of the processed surface to a low level by adjusting the conditions for the grinding. In particular, by setting the load P1 in the first stage in a range of 130 to 200 g/cm² and the load P2 in the second stage in a range of 50 to 120 g/cm², favorable results can be obtained.

It should be noted that if the load P1 in the first stage is smaller than 130 g/cm² (example 7), the period of time during which no grinding is performed cannot be reduced sufficiently, and therefore, the processing speed decreases. On the other hand, if the load P1 in the first stage is larger than 200 g/cm² (example 8), the cuts made by the abrasive particles are too deep, thus causing scratches.

Therefore, it is necessary to increase the machining allowance of the main processing and subsequent steps, and the total processing time is extended.

That is, from the viewpoint of a processing speed, P1 is preferably 130 g/cm² or more, and from the viewpoint of scratches, P1 is preferably 200 g/cm² or less.

Moreover, from the above-described results, P1/P2 is preferably 1.20 or more or 3.0 or less.

[0078]

Moreover, as another example (comparative example), a glass substrate was processed in the same manner as in example 1, except that P1 was set to 100 (g/cm²) and P2 was set to 130 (g/cm²). When the glass substrate was evaluated, Ra was 0.132 μm, and thus it was found that the manufacturing cost cannot be reduced since it is necessary to increase the machining allowance in the subsequent polishing step.

[0079]

Moreover, continuous processing of fifty batches was performed under the conditions for each example shown in Table 2 while using a new glass substrate at every time, and 2500 processed glass substrates in total were examined. As a

result, one substrate, among the glass substrates ground under the conditions for example 9, in which a portion of the main surfaces had not been ground was found. Such non-ground substrates can be found by the same method as in inspecting for scratches.

5 Furthermore, the same continuous processing as described above was performed under the same conditions as in example 4, except that P1 was changed to 160 (g/cm²) and 140 (g/cm²) (respectively referred to as examples 11 and 12, in which P1/P2 was respectively 3.2 and 2.8). As a result, no non-ground substrates as described above were found in the case where P1 was set to 140 (g/cm²), and
10 one non-ground substrate was found in the case where P1 was set to 160 (g/cm²).

That is, it was found from the results of examples 4, 9, 11 and 12 that if P1/P2 was greater than 3, there was a risk that a non-ground substrate would be produced when performing continuous processing.

[0080] Moreover, the amount of projection of the abrasive particles (aggregates) in
15 the diamond pads used in example 1 was changed in a range of 0.3 to 8 μm .

Other than this, grinding was continuously performed in the same manner as in example 1, and the surfaces of the resulting 2500 glass substrates were observed. Table 3 below shows the observation results.

[0081]

20 [Table 3]

Table 3	Amount of projection of abrasive particles	Check results for 2,500 substrates
Example 13	0.3 μm	15 non-ground substrates
Example 14	0.5 μm	No non-ground substrates and no scratches
Example 15	7 μm	No non-ground substrates and no scratches
Example 16	8 μm	Scratches detected in 24 substrates

[0082]

From the results shown in Table 3 above, the amount of projection of the abrasive particles is particularly preferably in a range of 0.5 to 7 μm on the surface of the diamond pads used in the grinding.

[0083]

(Manufacture of magnetic disk)

A magnetic disk for perpendicular magnetic recording was manufactured by performing the following film forming step on the magnetic-disk glass substrates
5 obtained in example 1 described above.

Specifically, an adherent layer consisting of a Ti-based alloy thin film, a soft magnetic layer consisting of a CoTaZr alloy thin film, a base layer consisting of a Ru thin film, a perpendicular magnetic recording layer made of a CoCrPt alloy, a carbon protecting layer, and a lubricant layer were sequentially formed on the glass
10 substrate. The protective layer is to prevent degradation of the magnetic recording layer caused by contact with the magnetic head. The protective layer is composed of hydrogenated carbon and yields wear resistance. The lubricant layer was formed by a dipping method using an alcohol-modified perfluoropolyether liquid lubricant.

15 The resulting magnetic disk was incorporated into an HDD equipped with a DFH head, and then subjected to load/unload durability testing for one month while operating the DFH function in a high temperature and high humidity environment at a temperature of 80°C and a humidity of 80%RH. This resulted in no particular failures, and favorable results were obtained.

20

Description of Reference Signs

[0084]	1	Diamond pad
	2	Sheet
	3	Aggregate
25	4	Pellet
	5	Diamond particle
	6	Supporting material
	10	Glass substrate

CLAIMS

1. A method for manufacturing a magnetic-disk glass substrate comprising grinding processing for grinding a main surface of a glass substrate using a lubricant and a surface plate having a grinding surface provided with fixed
5 abrasive particles including diamond particles,
wherein the main surface of the glass substrate is a mirror surface,
the grinding processing has a first stage in which the surface of the glass substrate is roughened with a higher load than a load applied in grinding and a second stage in which the surface of the glass substrate is ground with a lower load
10 than the load applied in the first stage, after the first stage, and
the grinding processing having the first stage and the second stage is performed using a same device.
2. The method for manufacturing a magnetic-disk glass substrate
15 according to claim 1, wherein $P1/P2$ is 3.0 or less, where $P1$ (g/cm^2) is a load applied in the first stage and $P2$ (g/cm^2) is a load applied in the second stage.
3. The method for manufacturing a magnetic-disk glass substrate according to claim 2, wherein $t1 < t2$, where $t1$ is a period of time the load $P1$ is
20 maintained in the first stage and $t2$ is a period of time the load $P2$ is maintained in the second stage.
4. The method for manufacturing a magnetic-disk glass substrate according to any of claims 1 to 3, wherein a surface roughness of the main surface
25 of the glass substrate to be ground is $0.05\text{ }\mu\text{m}$ or less in Ra .
5. The method for manufacturing a magnetic-disk glass substrate according to any of claims 1 to 4, wherein a processing speed in the grinding processing is 3.0 to $9.0\text{ }\mu\text{m}/\text{minute}$.

6. The method for manufacturing a magnetic-disk glass substrate according to any of claims 1 to 5, wherein a surface roughness of the glass substrate after the second stage is 0.080 to 0.130 μm in Ra.

5

7. A method for manufacturing a magnetic disk in which at least a magnetic layer is formed on the magnetic-disk glass substrate manufactured by the method for manufacturing a magnetic-disk glass substrate according to any of claims 1 to 6.