

DESCRIPTION

[Title of Invention]

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

[Technical Field]

[0001] The present invention relates to a method for manufacturing a magnetic-disk substrate and a method for manufacturing a magnetic disk.

10 [Background Art]

[0002] Conventionally, a glass substrate has been preferably used in a magnetic disk used as one type of information recording medium. Nowadays, in order to meet the demand for an increase in the storage capacity of hard disk drive apparatuses, attempts have been made to increase the magnetic recording density. Accompanying this, the magnetic recording information area has been made smaller by making the flying height of the magnetic head from the magnetic recording surface extremely low. In such a magnetic-disk glass substrate, in order to achieve a lower flying height of the magnetic head, which is necessary for a hard disk drive apparatus with a high-recording density, demand for a decrease in surface unevenness of the glass substrate, and in particular, demand for a decrease in microwaviness has been increasing.

[0003] In order to reduce surface unevenness, and in particular, microwaviness of the glass substrate, it is necessary to perform polishing processing on the glass substrate with high precision. In the polishing processing, main surfaces of the glass substrate are polished by sliding the polishing pads and the glass substrate relative to each other. In order to perform the polishing processing with high precision, polishing conditions, for example, conditions of the polishing pads and a polishing slurry are adjusted. In particular, the polishing pad is a member that comes into direct contact with
25
30 the glass substrate, and thus significantly affects the surface unevenness of the

glass substrate. Such a polishing pad is obtained by performing dressing before the start of the polishing of the glass substrate so as to achieve a predetermined flatness and surface roughness of a surface of the polishing pad.

For example, a technique has been known in which a plate-shaped
5 dressing jig used in dressing is used in a method for polishing a glass substrate in which the glass substrate is polished with a dressed polishing pad for a glass substrate, the dressing jig being such that the surface roughness of a plate surface is 0.10 μm to 2.5 μm in terms of the arithmetic average roughness Ra and an amount of change in an arithmetic average roughness Ra of the plate
10 surface before and after dressing is 15% or more (PLT 1).

[Citation List]

[Patent Literature]

[0004] [PLT1]: Japanese Patent 5428793

[Summary of Invention]

15 [Technical Problem]

[0005] In recent years, in order to achieve a lower flying height of the magnetic head, stricter management of microwaviness among surface roughnesses of main surfaces of a glass substrate is in demand. For example, among surface roughnesses, it is preferable to reduce microwaviness (wavelength is 50 to 200
20 μm) in a specific region with relatively shorter wavelengths than that of the conventional microwaviness (wavelength is 2 μm to 4 mm).

If an attempt is made to realize a decrease in microwaviness having a wavelength of 50 to 200 μm on the glass substrate, microwaviness having a short wavelength on the glass substrate cannot always be reduced by merely
25 using the above-described dressing jig. Such a problem in glass substrates also arises in a substrate made of an aluminum alloy that is made into a magnetic-disk substrate by performing polishing processing.

[0006] In view of this, an object of the present invention is to provide a method for manufacturing a magnetic-disk substrate and a method for manufacturing
30 a magnetic disk with which microwaviness having a wavelength of 50 to 200

μm among surface roughnesses of the substrate after polishing processing, on a main surface of the substrate can be reduced.

[Solution to Problem]

[0007] The inventor of the present application studied the relationship
5 between surface roughnesses of a polishing pad used in polishing processing performed such that the surface roughness of a main surface of a magnetic-disk glass substrate satisfies the quality requirements for the magnetic-disk glass substrate and microwavinesses having wavelengths of 50 to 200 μm on the main surface of the glass substrate after the polishing processing using the
10 polishing pad, and found that there is a correlational relationship between surface roughnesses of the polishing pad and microwavinesses having wavelengths of 50 to 200 μm on the main surface of the glass substrate. Moreover, the inventor of the present application found that there is a correlational relationship between surface roughnesses of a resin foam material,
15 which is the raw material for the polishing pad, before opening formation processing is performed in which openings are formed in the surface of the polishing pad by shaving the surface of the resin foam material and surface roughnesses of the resin foam material after the opening formation processing. Based on such a correlational relationship, the inventor accomplished the
20 present invention.

[0008] That is, an aspect of the present invention is a method for manufacturing a magnetic-disk substrate. The manufacturing method includes the following aspects.

[0009] Aspect 1

25 A method for manufacturing a magnetic-disk substrate, including:
polishing processing for polishing a main surface of a substrate by sliding a polishing pad and the substrate relative to each other; and
opening formation processing in which openings are formed in a surface of a raw material for the polishing pad having no openings by shaving the
30 surface of the raw material before the polishing processing, in order to make

the raw material into the polishing pad,

in which the raw material having an arithmetic average roughness Ra of 0.65 μm or less among surface roughnesses of the surface is used as the raw material for the polishing pad.

5 [0010] Aspect 2

A method for manufacturing a magnetic-disk substrate, including:

polishing processing for polishing a main surface of a substrate by sliding a polishing pad and the substrate relative to each other; and

opening formation processing in which openings are formed in a surface
10 of a raw material for the polishing pad having no openings by shaving the surface of the raw material before the polishing processing, in order to make the raw material into the polishing pad,

in which a correlational relationship between surface roughnesses of the raw material before the opening formation processing and surface
15 roughnesses of the raw material after the opening formation processing is obtained in advance, and

the raw material for the polishing pad that has not undergone the opening formation processing is selected by defining a surface roughness of the raw material that has not undergone the opening formation processing based
20 on the correlational relationship and information on a surface roughness of the raw material resulting from the opening formation processing according to which a surface roughness having a wavelength of 50 to 200 μm on the main surface of the substrate resulting from the polishing processing falls within a set range.

25 [0011] Aspect 3

The method for manufacturing a magnetic-disk substrate according to Aspect 1 or 2, in which an average diameter of the openings of the raw material after the opening formation processing is 1 to 50 μm .

[0012] Aspect 4

30 The method for manufacturing a magnetic-disk substrate according to

any one of Aspects 1 to 3, in which in the opening formation processing, an amount by which the raw material is shaved is 5 μm or less.

[0013] Aspect 5

5 The method for manufacturing a magnetic-disk substrate according to any one of Aspects 1 to 4, in which a thickness of the raw material after the opening formation processing is 300 to 800 μm .

[0014] Aspect 6

The method for manufacturing a magnetic-disk substrate according to any one of Aspects 1 to 5,

10 in which the raw material is a resin foam material, and
a ratio between an arithmetic average roughness $Ra1$ of the surface of the resin foam material before the opening formation processing is performed and an arithmetic average roughness $Ra2$ of the surface of the resin foam material after the opening formation processing is performed is such that
15 $1 < Ra2/Ra1 \leq 4$, and an arithmetic average roughness Ra of the resin foam material after the opening formation processing is performed is 1.0 μm or less.

[0015] Aspect 7

The method for manufacturing a magnetic-disk substrate according to any one of Aspects 1 to 6, in which with regard to microwaviness having a
20 wavelength of 50 to 200 μm after the main surface of the substrate is polished, a root mean square roughness Rq of the substrate is 0.06 nm or less.

[0016] Another aspect of the present invention is a method for manufacturing a magnetic-disk substrate, and includes the following aspect.

[0017] Aspect 8

25 In the method for manufacturing a magnetic-disk substrate, at least a magnetic layer is formed on a main surface of the magnetic-disk substrate manufactured with the method for manufacturing a magnetic-disk substrate according to any one of Aspects 1 to 7.

[Advantageous Effects of the Invention]

30 [0018] Microwaviness having a wavelength of 50 to 200 μm on a main surface

of a substrate after polishing processing can be reduced with the above-described method for manufacturing a magnetic-disk substrate and method for manufacturing a magnetic disk.

[Brief Description of Drawings]

5 [0019] FIGS. 1(a) and 1(b) are schematic configuration diagrams of a polishing apparatus used in second polishing processing in the present embodiment.

FIG. 2 is a diagram illustrating polishing with the polishing apparatus shown in FIGS. 1(a) and 1(b)

10 FIGS. 3(a) and 3(b) are diagrams illustrating the structure and surface shape of a resin foam material that is the raw material for a polishing pad.

FIG. 4 is a diagram expressing a correlational relationship between arithmetic average roughnesses R_a of the surface of the resin foam material before opening formation processing and arithmetic average roughnesses R_a of the surface of the resin foam material that has undergone the opening
15 formation processing.

FIG. 5 is a diagram expressing a relationship between arithmetic average roughnesses R_a of the surface of the resin foam material before the opening formation processing and root mean square roughnesses R_q of the main surface of the glass substrate after the second polishing processing.

20 [Description of Embodiments]

[0020] Hereinafter, a method for manufacturing a magnetic-disk substrate and a magnetic-disk substrate of the present embodiment will be described in detail. Note that although the magnetic-disk substrate of the present invention can be applied to an aluminum alloy substrate in addition to the glass substrate, the
25 magnetic-disk glass substrate is used as this embodiment in the following description. Definitions of surface roughnesses including the root mean square roughness R_q and the arithmetic average roughness R_a of microwaviness having a wavelength of 50 to 200 μm in this specification conform to JIS B 0601: 2001.

30 [0021] In the present embodiment, a magnetic-disk glass substrate used in a

magnetic disk has a disk shape, a central portion is hollowed out in a concentric shape so that the magnetic disk has a ring shape, and the magnetic disk rotates using the center of the ring as the rotation axis. The magnetic disk is obtained by stacking a magnetic layer and the like on the magnetic-disk glass substrate.

- 5 For example, an adherent layer, a soft magnetic layer, a nonmagnetic base layer, a vertical magnetic recording layer, a protecting layer, a lubricant layer, and the like are formed on the glass substrate. Accordingly, a magnetic disk is manufactured. Thus, it is important to precisely manage the surface unevenness of the magnetic-disk glass substrate.
- 10 [0022] For example, urethane foam, which is the resin foam material, is used in a polishing pad that is used in processing for polishing a glass substrate of the present embodiment, such as a polishing pad used in polishing processing (second polishing processing). This resin foam material has a void layer (a void layer 24e shown in FIG. 3(b)) having an independent bubble structure
- 15 whose inner portion is provided with a plurality of voids, and a surface film (surface film 24d shown in FIG. 3(b)) provided on the surface side of the void layer, and the polishing pad is a so-called suede polishing pad having a portion in which a void cross section decreases in size from the inner portion to the surface of the polishing pad. Opening formation processing in which void
- 20 openings are evenly formed in the surfaces of the polishing pad by shaving at least a surface film of this resin foam material has been performed on this polishing pad. This opening formation processing is performed before processing for polishing the glass substrate. This resin foam material is the raw material for the polishing pad. The resin foam material on which the
- 25 opening formation processing has been performed refers to a raw material on which the opening formation processing has been performed or a resin foam material that has undergone the opening formation processing.

In the present embodiment, a resin foam material having, among surface roughnesses of a surface film of the resin foam material, an arithmetic

30 average roughness Ra of 0.65 μm or less before the opening formation

processing is used as the raw material for the polishing pad. Microwaviness (root mean square roughness R_q) at a wavelength of 50 to 200 μm on a main surface of a glass substrate that has undergone the polishing processing can be set to 0.06 nm or less with using, in the polishing processing, the raw material
 5 obtained by performing the opening formation processing on the raw material for this polishing pad.

The inner portion of the resin foam material, which is the raw material for the polishing pad, has a plurality of voids having different sizes, for example, and the shape of a void is a droplet shape in which the cross section of the void
 10 decreases in size from the inner portion to the surface of the material. Small voids are located in the vicinity of the surface film, and large voids are located in the inner portion. However, tip portions of droplet shapes of both small voids and large voids face the surface, and their leading edges are located at substantially the same depth from the surface of the surface film. Thus, the
 15 surface roughness can be reduced by, in the opening formation processing, shaving a resin foam material from its surface to long narrow portions of the above-described tips, the surface of the surface film of the resin foam material having an arithmetic average roughness R_a of 0.65 μm or less, and openings having approximately the same opening diameter are formed in the surface.
 20 Therefore, among surface roughnesses of the glass substrate, a root mean square roughness R_q of microwaviness in a wavelength band of 50 to 200 μm can be set to 0.06 nm or less by performing polishing processing using the resin foam material that has undergone the opening formation processing as the polishing pad for the glass substrate.

25 [0023] An example of the method for manufacturing a magnetic-disk glass substrate of the present embodiment including polishing processing for polishing a glass substrate using such a polishing pad will be described below.

First, a glass blank that serves as the blank for a plate-shaped magnetic-disk glass substrate having a pair of main surfaces is molded. Next,
 30 this glass blank is processed as appropriate to produce a ring-shaped (annular)

glass substrate that has a hole in the central portion and has a chamfered edge portion. Accordingly, the glass substrate is produced. Thereafter, polishing processing is performed on the main surfaces to reduce microwaviness having a wavelength of 50 μm to 200 μm . The polishing processing may be divided into
 5 a plurality of processes as needed. Also, the main surface may be ground, an edge surface (including the chamfered portion) may be polished, and chemical strengthening may be performed as needed. In this case, the order of processes may be determined as appropriate.

Hereinafter, the respective processes will be described.

10 [0024] (a) Glass blank molding processing

A float method is used, for example, in molding of a glass blank. In the glass blank molding processing, first, plate-shaped glass having the above-described composition, for example, is obtained by continuously pouring molten glass into a bath filled with molten metal such as tin. The molten
 15 glass flows in an advancing direction in the bath where the temperature is strictly controlled, and ultimately the plate-shaped glass adjusted to a desired thickness and width is formed. A plate-shaped glass blank with a predetermined shape (a shape that is quadrangular in plan view, for example) from which a magnetic-disk glass substrate is to be made is cut out from this
 20 plate-shaped plate glass.

Also, the plate-shaped glass blank can also be molded with a press molding method, for example, instead of the float method. Furthermore, the plate-shaped glass blank can be manufactured using a known manufacturing method such as a down draw method, a redraw method, or a fusion method. A
 25 disk-shaped glass blank from which a magnetic-disk glass substrate is to be made is cut out by performing appropriate shaping processing on the plate-shaped glass manufactured with these known manufacturing methods.

[0025] (b) Shaping processing

Next, in shaping processing, a disk-shaped glass substrate having a
 30 circular through hole is produced by forming a circular hole using a known

processing method after the glass blank molding processing. Thereafter, chamfering may be further performed. Also, the main surfaces may be ground in order to adjust the thickness and reduce the flatness, for example.

[0026] (c) First polishing processing

5 Next, first polishing processing is performed on the main surfaces of the glass substrate. The first polishing processing is performed in order to mirror-polish the main surfaces. Specifically, the main surfaces on both sides of the glass substrate are polished while the glass substrate is held in a holding hole provided in a holding member (carrier) that is attached to a double-side
10 polishing apparatus. The machining allowance for first polishing is about several micrometers to 100 μm , for example. The first polishing processing is performed in order to eliminate blemishes and distortions that remain on the main surfaces and to adjust minute unevenness of the surface, for example. Note that in order to further reduce or more finely adjust surface unevenness,
15 the first polishing processing may be divided into a plurality of polishing processes.

[0027] In the first polishing processing, the glass substrate is polished while a polishing slurry is supplied, using a known double-side polishing apparatus that includes an upper surface plate, a lower surface plate, an internal gear,
20 carriers, and a sun gear, and that has a planetary gear mechanism. In the first polishing processing, a polishing slurry containing polishing abrasive particles (loose abrasive particles) is used. Abrasive particles (particle size: diameter of about 0.3 to 3 μm) of cerium oxide, aluminum oxide, zirconia, or colloidal silica, for example, are used as the loose abrasive particles that are
25 used in the first polishing. In the double-side polishing apparatus, the glass substrate is held between the pair of upper and lower surface plates. Tubular polishing pads (polishers made of resin, for example) each having an annular shape as a whole are attached to the upper surface of the lower surface plate and the bottom surface of the upper surface plate. The glass substrate and the
30 surface plates are moved relative to each other by one or both of the upper

surface plate and the lower surface plate being moved whereby both main surfaces of the glass substrate are polished.

[0028] (d) Chemical strengthening processing

The glass substrate can be chemically strengthened as appropriate. A
5 molten liquid obtained by heating potassium nitrate, sodium nitrate, or a mixture thereof, for example, to 300°C to 500°C can be used as a chemical strengthening liquid. The glass substrate is then immersed in the chemical strengthening liquid for 1 hour to 10 hours, for example.

Although timing at which the chemical strengthening processing is
10 performed can be determined as appropriate, it is particularly preferable that polishing processing is performed after the chemical strengthening processing because it is possible to smooth the surface and remove foreign matter adhering to the surface of the glass substrate through the chemical strengthening processing. It is not essential to perform the chemical strengthening
15 processing.

[0029] (e) Second polishing processing

Next, second polishing processing is performed on the glass substrate that has undergone the chemical strengthening or the glass substrate that has undergone the first polishing processing. The second polishing processing is
20 performed in order to further smooth the main surfaces on which the first polishing processing has been performed. A double-side polishing apparatus having a configuration similar to that of the double-side polishing apparatus that is used in the first polishing is used in the second polishing as well. The machining allowance for the second polishing is about 0.5 μm to 10 μm , for
25 example.

In the second polishing processing, polishing is performed using a slurry containing loose abrasive particles. Colloidal silica is preferably used as the loose abrasive particle. The average particle diameter of the colloidal silica is preferably 5 nm or more and 50 nm or less in light of the fact that
30 microwaviness having a wavelength of 50 to 200 μm on a main surface of a

glass substrate G is reduced. If the average particle diameter is larger than 50 nm, there is a concern that the microwaviness having a wavelength of 50 to 200 μm cannot be reduced sufficiently. Also, there is a concern that the surface roughness cannot be reduced sufficiently. On the other hand, if the

5 average particle diameter is less than 5 nm, there is a concern that the polishing rate will dramatically decrease and productivity will decrease.

Note that in the present embodiment, the above-described average particle diameter denotes a particle diameter at which a cumulative curve reaches 50% when the cumulative curve is obtained by setting the total volume

10 of powder particles in the particle size distribution measured with a laser diffraction method to 100% (also referred to as "cumulative average particle diameter (50% diameter)", or D50).

FIGS. 1(a) and 1(b) are schematic configuration diagrams of a polishing apparatus 10 that is used in the second polishing processing. A similar

15 apparatus can also be used in the first polishing.

[0030] As shown in FIGS. 1(a) and 1(b), the polishing apparatus 10 includes a lower surface plate 12, an upper surface plate 14, an internal gear 16, carriers 18, polishing pads 20, and a sun gear 22.

The polishing apparatus 10 sandwiches the internal gear 16 between

20 the lower surface plate 12 and the upper surface plate 14 from above and below. The internal gear 16 holds a plurality of carriers 18 at the time of polishing. Five carriers 18 are shown in FIG. 1(b). The polishing pads 20 are attached in a planar manner to the lower surface plate 12 and the upper surface plate 14. The lower surface plate 12 and the upper surface plate 14 are configured to

25 rotate (revolve) around a rotation axis of the lower surface plate 12 and the upper surface plate 14.

[0031] FIG. 2 is a cross-sectional view taken along line A-A shown in FIG. 1(b), illustrating polishing of a polishing apparatus. As shown in FIG. 2, the carriers 18 are arranged such that the main surfaces on the lower side of the

30 glass substrates G come into contact with the polishing pad 20 on the lower

surface plate 12 and the main surfaces on the upper side of the glass substrates G come into contact with the polishing pad 20 on the upper surface plate 14. By performing polishing in such a state, the main surfaces on both sides of the glass substrates G that were formed into an annular shape can be polished.

5 [0032] As shown in FIG. 1(b), the annular glass substrates G are held in circular holes provided in the carriers 18. On the other hand, the glass substrates G are held above the lower surface plate 12 by the carrier 18, which each have a gear 19 on the outer circumference. The carrier 18 engages with the sun gear 22 and the internal gear 16 provided in the lower surface plate 12.

10 Due to the sun gear 22 being rotated in the direction of the arrow shown in FIG. 1(b), the carriers 208 respectively revolve while rotating as planet gears in the arrow direction. Accordingly, the glass substrate G is polished using the polishing pads 20. At the time of polishing, the glass substrate G is polished by being pressed at 0.002 to 0.02 MPa, for example. The slurry that is used in

15 the polishing is supplied to the upper surface plate 14 as shown in FIG. 1(a), flows to the lower surface plate 12, and is collected in an external container.

[0033] Note that the type, particle diameter, and variation in the particle diameter of the loose abrasive particles that are used in the second polishing processing, the hardness of a resin used for the polishing pad 20, the opening

20 diameter of a later-described pore on the surface of the polishing pad 20, and the like are changed from those in the first polishing as appropriate. In the present embodiment, in order to reduce microwaviness having a wavelength of 50 to 200 μm on the polished glass substrate in at least the polishing processing, the surfaces of the polishing pads 20 are managed through the opening

25 formation processing.

After the second polishing, the glass substrate G is cleaned to obtain a magnetic-disk glass substrate. Note that after the second polishing, polishing processing with which surface unevenness including the surface roughness and microwaviness of the main surfaces of the glass substrate do not change may be

30 further performed.

The magnetic disk is produced thereafter by providing a magnetic layer on a main surface of the magnetic-disk glass substrate. For example, an adherent layer, a soft magnetic layer, a nonmagnetic base layer, a vertical magnetic recording layer, a protecting layer, a lubricant layer, and the like are
5 formed on the surface of the magnetic disk.

[0034] Although the description was given using a glass substrate as a magnetic-disk substrate, as described above, the present invention can also be applied to an aluminum alloy substrate. If the present invention is applied to an aluminum alloy substrate, an aluminum alloy substrate obtained by
10 forming NiP plating on a surface of an aluminum alloy blank obtained by rolling an aluminum alloy and cutting the resulting aluminum alloy into a disk shape is used, and the surface with the NiP plating film is polished using a polishing pad. A magnetic disk obtained using the aluminum alloy substrate can be obtained by stacking a soft magnetic layer, a nonmagnetic base layer, a
15 vertical magnetic recording layer, a protecting layer, a lubricant layer, and the like on the aluminum alloy substrate.

Specifically, when the aluminum alloy substrate is manufactured through the following processing steps, the polishing pad used in a polishing processing step may be the same as that used in the step of polishing a glass
20 substrate.

A molten aluminum alloy is cast, rolled, and then cut into a disk-shaped aluminum alloy blank, and then main surfaces and edge surfaces are subjected to grinding processing so as to have predetermined dimensions. Thereafter, processing for forming a NiP plating film with a thickness of 5 to 30 μm is
25 performed on a surface of the aluminum alloy blank so as to produce an aluminum alloy substrate. Subsequently, microwaviness is reduced by subjecting a main surface of the aluminum alloy substrate with NiP plating to polishing processing using polishing pads. In general, the polishing processing is performed in two stages with different types and particle
30 diameters of polishing abrasive particles, and blemishes and waviness on the

NiP plating surface of the aluminum alloy substrate surface are reduced by sandwiching the aluminum alloy substrate between polishing pads on which opening formation processing has been performed and sliding the polishing pads and the substrate relative to each other, a slurry containing aluminum
 5 oxide abrasive particles having an average particle diameter of 0.3 to 3 μm being used in first polishing processing, and a slurry containing colloidal silica abrasive particles having an average particle diameter of 5 to 50 nm being used in second polishing processing. Furthermore, after both the first polishing processing and the second polishing processing, cleaning processing for
 10 removing particles such as polishing abrasive particles and polishing residue that attaches to the substrate surfaces after the polishing processing.

[0035] Polishing pad

The polishing pad 20 that is used in polishing processing in the present embodiment is made of polyurethane foam, for example. A surface of the raw
 15 material for a polishing pad that has not been used in the polishing processing, that is, the resin foam material 24, has a surface film and is not provided with openings, and the inner portion of the resin foam material 24 has an independent bubble structure including voids 24a and 24b that have different sizes. FIGS. 3(a) and 3(b) are cross-sectional views illustrating the structure
 20 of the resin foam material 24 in a state of the raw material for the polishing pad. Both the voids 24a and 24b have a droplet shape, and have a shape that tapers off toward a surface 24c. If the surface 24c of such a resin foam material 24 on which the surface film is provided is shaved, the following is conceivable with regard to the surface unevenness of the surface 24c.

25 As shown in FIG. 3(a), if the surface roughness of the surface 24c is high and the surface 24c has waviness, when the resin foam material 24 is shaved to line X1 through the opening formation processing, minute chattering vibration caused by the waviness of the surface 24c is likely to occur between the resin foam material 24 and the jig used in the opening formation processing. Also,
 30 as shown in FIG. 3(a), openings formed on the surface have different sizes

depending on the locations of recessed portions and protruding portions of the waving surface 24c, and when the surface 24c is shaved, the resistance that the jig receives from the surface 24c tends to fluctuate, and thus minute chattering vibration tends to occur. Thus, the surface roughness of the polishing pad
 5 after the opening formation processing increases due to this chattering vibration.

Also, as shown in FIG. 3(a), openings formed on the surface have different sizes depending on the locations of recessed portions and protruding portions of the waving surface 24c. For example, an opening is formed at a
 10 portion of a void 24b having a large cross section in a region of a protruding portion on the surface 24c, whereas an opening is formed at a tip portion of a void 24b having a small cross section in a region of a recessed portion. Similarly, the cross section of the void 24a that crosses the line X1 also changes depending on the locations of the recessed portions and the protruding portions
 15 of the waving surface 24c. Thus, if the glass substrate is polished using the resin foam material 24 having openings with different sizes as the polishing pads 20, microwaviness having a wavelength of 50 to 200 μm on a main surface of the glass substrate increases due to variation resulting from the locations of openings of the polishing pad 20.

As shown in FIG. 3(b), the above-described chattering vibration is
 20 unlikely to occur in the resin foam material 24 in which the surface roughness of the surface 24c is small and the surface 24c approximately does not have waviness. Thus, compared to the case shown in FIG. 3(a), the surface roughness of the resin foam material 24 after the opening formation processing
 25 decreases.

Furthermore, as shown in FIG. 3(b), if the resin foam material 24 is shaved through the opening formation processing from the surface 24c to line X2, the sizes of the openings are approximately constant. Therefore, in the present embodiment, with regard to the resin foam material having a small
 30 surface roughness before the opening formation processing, and specifically,

with regard to the surface roughness of the surface film of the resin foam material, a resin foam material in which an arithmetic average roughness R_a among surface roughnesses of the surface 24c is $0.65\text{ }\mu\text{m}$ or less is used as the raw material for the polishing pad 20. If the glass substrate is polished using
5 the resin foam material 24 having such openings as the polishing pad 20, variation due to the locations of openings on the polishing pad 20 decreases, and thus microwaviness having a wavelength of 50 to $200\text{ }\mu\text{m}$ on the main surface of the glass substrate can be reduced.

[0036] Note that as shown in FIG. 3(b), if the surface 24c has a small surface
10 roughness and opening formation processing for providing openings is performed by shaving the resin foam material from the surface 24c to a certain depth, compared to shaving to line X3, it is preferable to perform shaving to the line X2 such that openings are formed at the tip portions of the droplet shapes of the voids 24a and 24b having different sizes. If the resin foam material is
15 shaved to line X3, an opening is formed at a portion having a relatively small void cross section in the large void 24b, whereas an opening is formed at a portion having a large void cross section in the small void 24a, and thus the sizes of the openings tend to vary. It is preferable that in the opening formation processing, an amount by which the resin foam material 20 is shaved
20 is thicker than the thickness of the surface film 24d and is $5\text{ }\mu\text{m}$ or less, considering the depths of the leading edges of the voids 24a and 24b from the surface 24c. Also, it is preferable that an average diameter of the openings of the voids that are provided with such opening formation processing is 1 to $50\text{ }\mu\text{m}$ in light of the fact that microwaviness of the main surfaces of the glass
25 substrate is reduced. In this case, the average diameter of the openings is a value obtained by measuring an image of the opening portions with a laser microscope and analyzing the image. Specifically, with regard to ten openings of bubbles located on a straight line drawn at an arbitrary position on an image of a surface imaged at an appropriate magnification, the maximum dimension
30 of each opening was obtained and an average value of the maximum

dimensions was used as the average diameter of the openings.

Also, the thickness of the resin foam material 24 (the thickness of the raw material for the polishing pad after the opening formation processing) serving as the polishing pad 20 used in the polishing processing, that is, the thickness of the resin foam material that has undergone the opening formation processing is preferably 300 to 800 μm in light of the fact that microwaviness of the main surfaces of the glass substrate is reduced. The polishing pad 20 has a structure in which the resin foam material 24 is stacked via a base layer on the base made of a PET resin material or the like having a high rigidity.

[0037] Note that the opening formation processing is performed in a state in which the polishing pads 20 are attached to the lower surface plate 12 and the upper surface plate 14 in the polishing apparatus 10 shown in FIGS. 1(a), 1(b), and 2, using, instead of the carriers 18, disk-shaped dressers (jigs) that have surfaces on which diamond abrasive particles or the like are distributed and fixed, and are the same size as the carriers 18. That is, the opening formation processing is performed by sandwiching the dresser between the lower surface plate 12 and the upper surface plate 14, applying a predetermined pressure, and sliding the dresser and the polishing pads 20 relative to each other.

[0038] In this manner, in the present embodiment, in order to reduce microwaviness of the main surfaces of the glass substrate that has undergone the polishing processing, the resin foam material in which the arithmetic average roughness R_a among surface roughnesses of the surface film is 0.65 μm or less is used as the raw material for the polishing pad, and it is thereby possible to set microwaviness (root mean square roughness R_q) having a wavelength of 50 to 200 μm on the main surface of the glass substrate that has undergone the polishing processing to 0.06 nm or less.

Note that although the arithmetic average roughness R_a is used as the surface roughness of the resin foam material that has not undergone the opening formation processing and has undergone the opening formation processing in the present embodiment, R_z or R_q , which are defined in JIS B

0601: 2001 can be used instead of the arithmetic average roughness Ra. In this case, the Rz of the surface film before the resin foam material undergoes the opening formation processing is preferably 2.6 μm or less, and the Rq is preferably 0.85 μm or less.

5 [0039] Experimental Example

In order to check the effects of the present embodiment, resin foam materials that were the raw material for the polishing pads 20 and had different surface roughnesses were prepared, and opening formation processing was performed. Then, a correlational relationship between surface roughnesses of the resin foam materials that were the raw material for the polishing pads 20 and surface roughnesses of the resin foam materials that had undergone the opening formation processing was obtained in advance.

Polyurethane foam was used as the resin foam material. In the opening formation processing, the resin foam materials were shaved by 2 to 3 μm from their surfaces.

[0040] As the surface roughnesses of the resin foam materials before the opening formation processing and the surface roughnesses of the resin foam materials that had undergone the opening formation processing, the arithmetic average roughnesses Ra were obtained from the result of measurement of the surface roughnesses. The measurement method at that time was as follows.

A laser microscope for shape measurement was used as the measurement device, and a measurement area was set to 550 $\mu\text{m} \times 750 \mu\text{m}$. The measurement resolution in the height direction of the surface roughness was 0.5 nm. No low-pass cutoff value λ_s for the wavelength of a measured surface roughness was provided, and the high-pass cutoff value λ_c was 0.8 mm.

[0041] Also, a surface shape measurement device was used to obtain the root mean square roughnesses Rq of waviness having a wavelength of 50 to 200 μm in regions each having a radius of 14 mm to 31.5 mm on main surfaces of the glass substrates. Specifically, the surface shape was measured with a measurement pitch in the radial direction set to 0.01 mm and the number of

measurement regions in one circle in the circumferential direction set to 1024. A laser doppler vibrometer (LDV) was used as the surface shape measurement device. This measurement device is capable of measuring a wide wavelength band ranging from surface roughness to waviness. Because microwaviness
 5 having a wavelength of 50 μm to 200 μm was the measurement target, the root mean square roughness R_q was obtained using data obtained by performing filtering with a band-pass filter corresponding to a wavelength of 50 μm to 200 μm .

[0042] FIG. 4 is a diagram showing a graph of the measurement results and
 10 expressing the correlational relationship between arithmetic average roughnesses R_a (the horizontal axis of the graph shown in FIG. 4: R_a before opening formation processing) of the surface of the resin foam material before the opening formation processing and arithmetic average roughnesses R_a (the vertical axis of the graph shown in FIG. 4: R_a after opening formation
 15 processing) of the surface of the resin foam material that had undergone the opening formation processing.

[0043] Here, a polishing pad shown in FIG. 4 and a slurry containing colloidal silica abrasive particles having an average particle diameter of 20 nm were used to perform second polishing processing with a machining allowance of 2
 20 μm on the glass substrate on which the first polishing processing had been performed with a machining allowance of 30 μm using a usual polishing pad and a slurry containing cerium oxide abrasive particles having an average particle diameter of 1.5 μm . As a result, it was confirmed that in order to set the above-described root mean square roughness R_q of the main surfaces of the
 25 glass substrate to 0.06 nm or less, for example, it is sufficient that the arithmetic average roughness R_a of the surface of the resin foam material that undergone the opening formation processing is 1.00 μm or less, for example. In this case, it is preferable that the ratio between the arithmetic average roughness R_{a1} of the surface of the resin foam material before the opening
 30 formation processing and the surface roughness R_{a2} of the resin foam material

after the opening formation processing is such that $1 < \text{Ra2 after dressing} / \text{Ra1 before dressing} \leq 4$. In the polishing pads made of the resin foam material, if the value obtained by dividing Ra2 after dressing by Ra1 before dressing is 1 or less, it is difficult to perform dressing, whereas if the value obtained by dividing

5 Ra2 after dressing by Ra1 before dressing exceeds 4, the surface roughness of the polishing pad after dressing tends to increase, and thus it is not suitable for use as the polishing pad in a state of having openings formed through dressing. Furthermore, from the viewpoint of the workability resulting from dressing, it is preferable to set the arithmetic average roughness Ra of the surface of the

10 resin foam material before the opening formation processing to $0.65 \mu\text{m}$ or less. Thus, the correlational relationship shown in FIG. 4 is obtained in advance, an arithmetic average roughness Ra of the surface of the resin foam material before the opening formation processing is defined based on information on an arithmetic average roughness Ra of the surface of the resin foam material after

15 the opening formation processing according to which the above-described root mean square roughness Rq of the main surface of the glass substrate satisfies the required quality of the glass substrate and the correlational relationship that has been obtained in advance, and thereby it is possible to select a resin foam material for manufacturing a glass substrate that satisfies the quality

20 requested for the glass substrate. This makes it possible to set the surface roughness having a wavelength of 50 to $200 \mu\text{m}$, for example, the root mean square roughness Rq of the main surface of the glass substrate, to 0.06 nm or less.

[0044] Moreover, as shown in FIG. 4, upon comparing the arithmetic average

25 roughnesses Ra of the surface of the resin foam material before and after the opening formation processing, it is found that the arithmetic average roughness Ra after the opening formation processing is greater compared to the arithmetic average roughness Ra before the opening formation processing. Thus, conventionally, it was difficult to reduce the arithmetic average

30 roughness Ra of the resin foam material resulting from the opening formation

processing. However, the arithmetic average roughness Ra of the resin foam material after the opening formation processing can be reduced by finding the correlational relationship between arithmetic average roughnesses Ra before and after the opening formation processing, as shown in FIG. 4, in advance,
 5 and selecting an appropriate resin foam material that has not undergone foaming treatment.

[0045] FIG. 5 is a diagram expressing a relationship between arithmetic average roughnesses Ra of the surface of the resin foam material before the opening formation processing and root mean square roughnesses Rq of the
 10 main surface of the glass substrate after the second polishing processing. As is understood from FIG. 5, as the arithmetic average roughness Ra of the surface of the resin foam material before the opening formation processing approaches 0.65 μm from a region of being slightly larger than 0.65 μm , Rq sharply decreases, or in other words, when Ra is close to 0.65 μm , Rq critically
 15 changes to 0.06 nm or less. As a result of this, it is found that the root mean square roughness Rq of the main surface of the glass substrate after the second polishing processing can be set to 0.06 nm or less by setting the arithmetic average roughness Ra of the surface of the resin foam material that has not undergone the opening formation processing to 0.65 μm or less.

[0046] As described above, although a method for manufacturing a magnetic-disk substrate and a method for manufacturing a magnetic disk of the present invention have been described in detail, the present invention is not limited to the above-described embodiment and working examples, and it will be appreciated that various improvements and modifications can be made
 25 without departing from the gist of the present invention.

[Descriptions of Reference Numerals]

[0047] 10 Polishing apparatus
 12 Lower surface plate
 14 Upper surface plate
 30 16 Internal gear

	18	Carrier
	19	Gear
	20	Polishing pad
	22	Sun gear
5	24	Resin foam material
	24a, 24b	Void
	24c	Surface
	24d	Surface film
	24e	Void layer

CLAIMS

1. A method for manufacturing a magnetic-disk substrate, comprising:
polishing processing for polishing a main surface of a substrate by
5 sliding a polishing pad and the substrate relative to each other; and
opening formation processing in which openings are formed in a surface
of a raw material for the polishing pad having no openings by shaving the
surface of the raw material before the polishing processing, in order to make
the raw material into the polishing pad,
10 wherein a raw material having an arithmetic average roughness Ra of
0.65 μm or less among surface roughnesses of the surface is used as the raw
material for the polishing pad.
2. A method for manufacturing a magnetic-disk substrate, comprising:
15 polishing processing for polishing a main surface of a substrate by
sliding a polishing pad and the substrate relative to each other; and
opening formation processing in which openings are formed in a surface
of a raw material for the polishing pad having no openings by shaving the
surface of the raw material before the polishing processing, in order to make
20 the raw material into the polishing pad,
wherein a correlational relationship between surface roughnesses of the
raw material before the opening formation processing and surface roughnesses
of the raw material after the opening formation processing is obtained in
advance, and
25 the raw material for the polishing pad that has not undergone the
opening formation processing is selected by defining a surface roughness of the
raw material that has not undergone the opening formation processing based
on the correlational relationship and information on a surface roughness of the
raw material resulting from the opening formation processing according to
30 which a surface roughness having a wavelength of 50 to 200 μm on the main

surface of the substrate resulting from the polishing processing falls within a set range.

3. The method for manufacturing a magnetic-disk substrate according to
5 claim 1 or 2,

wherein an average diameter of the openings of the raw material after the opening formation processing is 1 to 50 μm .

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

wherein in the opening formation processing, an amount by which the raw material is shaved is 5 μm or less.

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

wherein a thickness of the raw material after the opening formation processing is 300 to 800 μm .

6. The method for manufacturing a magnetic-disk substrate according to
20 any one of claims 1 to 5,

wherein the raw material is a resin foam material, and

a ratio between an arithmetic average roughness Ra_1 of the surface of the resin foam material before the opening formation processing is performed and an arithmetic average roughness Ra_2 of the surface of the resin foam
25 material after the opening formation processing is performed is such that $1 < Ra_2/Ra_1 \leq 4$, and an arithmetic average roughness Ra of the resin foam material after the opening formation processing is performed is 1.0 μm or less.

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

wherein with regard to microwaviness having a wavelength of 50 to 200 μm after the main surface of the substrate is polished, a root mean square roughness R_q of the substrate is 0.06 nm or less.

- 5 8. A method for manufacturing a magnetic disk,
wherein at least a magnetic layer is formed on a main surface of the magnetic-disk substrate manufactured with the method for manufacturing a magnetic-disk substrate according to any one of claims 1 to 7.