

## DESCRIPTION

[Title of Invention]

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

5 [Technical Field]

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

[Background Art]

[0002] Magnetic disks are one type of information recording media mounted in  
10 magnetic recording apparatuses such as hard disk drive devices. Magnetic disks  
are configured with a thin film such as a magnetic layer formed on a substrate,  
and a glass substrate is used as the substrate. The surface of the glass substrate is  
precisely polished such that the flying height of the magnetic head of the  
magnetic recording apparatus can be lowered as much as possible to achieve a  
15 high recording density. In recent years, in order to meet the demand for hard disk  
drive devices with a larger storage capacity at lower cost, further quality  
improvement and cost reduction of magnetic-disk glass substrates are also  
required.

In recent years, in order to improve the quality of magnetic-disk glass  
20 substrates, the surface roughness of the glass substrate needs to be reduced and  
defects resulting from linear marks, minute extraneous matter, or the like on the  
surface need to be eliminated.

[0003] In order to realize a magnetic disk with a larger storage capacity that is  
produced using such a glass substrate, it is necessary to reduce the flying height  
25 of the magnetic head of the magnetic recording apparatus from the surface of the  
glass substrate. In order to reduce this flying height, it is desired to suppress  
defects resulting from marks or extraneous matter on the surface of the glass  
substrate as much as possible. In particular, it is not preferable that extraneous  
matter attaches to the surface of the glass substrate. In the production of glass  
30 substrates, as finishing polishing, the surface of the glass substrate is polished

using a polishing slurry containing colloidal silica having an extremely small particle diameter.

[0004] It is known that with a conventional method for polishing a glass substrate, linearly extending depression marks caused by polishing slurry, that is, linear marks (scratches) occur on a surface of the substrate. As a measure for reducing these scratches, a method is known in which, in the polishing process, the substrate is polished by supplying, to a polishing machine provided with surface plates, a polishing liquid composition at a flow rate of at least 0.06 cm<sup>3</sup>/min per 1 cm<sup>2</sup> of a polishing area of the substrate, the polishing liquid composition having a pH of 0.1 to 7, containing at least a polishing material and water, and containing not more than 500,000 polishing particles having a particle size of at least 0.56 μm and less than 1 μm per 1 cm<sup>3</sup> of the polishing liquid composition (Patent Literature 1).

Also, a method of performing polishing in a polishing process using a polishing liquid in which a ratio of dissolved silica to the overall silica is not more than 1000 ppm is known as a measure for reducing scratches (Patent Literature 2).

[CitationList]

[PatentLiterature]

[0005] [PLT1]:JP2006-102829A

[PLT2]: JP2010-95568A

[SummaryofInvention]

[TechnicalProblem]

[0006] In recent years, there is demand for a glass substrate for a magnetic disk having 750 gigabytes and the like, for example, and the need for reducing the surface roughness of a surface of the glass substrate and suppressing defects resulting from linear depressed marks or minute extraneous matter on the surface and is greater than ever. Thus, in some cases, the magnetic head comes into contact with the magnetic disk due to even defects having a protruding shape resulting from extraneous matter on the substrate that were not a problem conventionally, resulting in a crash. This means that even if the thickness of the extraneous matter on the glass substrate is several nanometers, for example, the

extraneous matter may cause a problem. The polishing methods disclosed in Patent Literatures 1 and 2 described above can reduce scratches on the glass substrate after polishing, but extraneous matter on the surface of the substrate is not mentioned at all.

5 [0007] In view of this, an object of the present invention is to provide a method for manufacturing a magnetic-disk glass substrate and a method for manufacturing a magnetic disk, with which extraneous matter that forms defects on the glass substrate can be reduced.

[Solution to Problem]

10 [0008] The present invention includes the following aspects.

[0009] Aspect 1

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

a step of polishing main surfaces on both sides of a glass substrate by pressing polishing pads against the main surfaces and moving the main surfaces  
15 and the polishing pads relative to each other while supplying a polishing slurry containing colloidal silica as polishing abrasive particles between the glass substrate and the polishing pads; and

a step of producing the polishing slurry by, before the main surfaces are polished, adjusting an original polishing slurry that serves as a basis of the  
20 polishing slurry to be used in the polishing processing to an acid state and removing, through filter processing, a silica deposit from the original polishing slurry generated by adjusting the original polishing slurry to the acid state.

[0010] Aspect 2

The method for manufacturing a magnetic-disk glass substrate according  
25 to Aspect 1, in which the original polishing slurry is an alkaline slurry.

[0011] Aspect 3

The method for manufacturing a magnetic-disk glass substrate according to Aspect 1 or 2, in which an original polishing slurry after adjustment to the acid state has a pH of 1 to 5.

30 [0012] Aspect 4

The method for manufacturing a magnetic-disk glass substrate according to any one of Aspects 1 to 3, in which a concentration of dissolved silica in the

polishing slurry is not more than 0.02 mass%.

[0013] Aspect 5

The method for manufacturing a magnetic-disk glass substrate according to any one of Aspects 1 to 4, in which the colloidal silica is obtained by heating active silicic acid obtained by ion exchanging an aqueous solution of sodium silicate with a cation exchange resin.

[0014] Aspect 6

The method for manufacturing a magnetic-disk glass substrate according to any one of Aspects 1 to 5, in which the polishing slurry, after being used to polish the main surfaces of the glass substrate, is collected and used to polish main surfaces of another glass substrate.

[0015] Aspect 7

The method for manufacturing a magnetic-disk glass substrate according to any one of Aspects 1 to 6, in which the colloidal silica has an average particle diameter of 10 to 100 nm.

[0016] Aspect 8

The method for manufacturing a magnetic-disk glass substrate according to any one of Aspects 1 to 7, in which the filter processing includes filtering with a depth-type filter and filtering with a cation-type filter after the filtration with the depth-type filter.

[0017] Aspect 9

A method for manufacturing a magnetic disk, in which at least a magnetic layer is formed on the main surfaces of the magnetic-disk glass substrate produced with the manufacturing method according to any one of Aspects 1 to 8.

[Advantageous Effects of the Invention]

[0018] According to the above-described method for manufacturing a magnetic-disk glass substrate and method for manufacturing a magnetic disk, extraneous matter that forms defects on the glass substrate can be reduced.

[Brief Description of Drawings]

[0019] FIG. 1 is a diagram illustrating a configuration of a polishing apparatus that executes polishing processing performed with a method for manufacturing a magnetic-disk glass substrate of this embodiment.

FIG. 2 is a diagram illustrating main portions of the polishing apparatus of this embodiment.

[Description of Embodiments]

[0020] Hereinafter, a method for manufacturing a magnetic-disk glass substrate and a method for manufacturing a magnetic disk of the present invention will be described in detail.

As a result of intensive studies on extraneous matter that forms defects on main surfaces of glass substrates, the inventor of the present invention found that extraneous matter on main surfaces of a glass substrate when a polishing slurry containing colloidal silica was used was silica aggregates or silica gel-like substances, and the extraneous matter strongly attached to the main surfaces of the glass substrate. It is inferred that this extraneous matter easily forms because both glass and silica contain a large amount of  $\text{SiO}_2$  and have similar properties. In view of this, the inventor found that in order to suppress extraneous matter on the main surfaces of the glass substrate, it is most important to suppress generation of silica aggregates and silica gel-like substances from the polishing slurry containing colloidal silica during polishing, and the inventor conceived of a technique including an embodiment described later.

Hereinafter, arithmetic average roughnesses  $R_a$  and  $R_{\text{max}}$ , which are indexes for a surface roughness described in the specification, are surface roughnesses defined in JIS B0601. This surface roughness is obtained based on data obtained by measuring a range of  $1\mu\text{m} \times 1\mu\text{m}$  using an atomic force microscope (AFM) at a resolution of  $512 \times 256$  pixels.

FIG. 1 is a diagram illustrating a configuration of a polishing apparatus that executes polishing processing performed with a method for manufacturing a magnetic-disk glass substrate of this embodiment. FIG. 2 is a diagram illustrating main portions of a polishing apparatus 1.

[0021] As shown in FIG. 1, the polishing apparatus 1 mainly includes a polishing main body portion 18, and an upper support table 12 and a lower support table 14 that support the polishing main body portion 18.

The upper support table 12 and the lower support table 14 are provided with a driving mechanism (not shown) for driving an upper rotary shaft 65 and a

lower rotary shaft 66 of the polishing main body portion 18, and the upper rotary shaft 65 and the lower rotary shaft 66 freely rotate due to this driving mechanism.

[0022] The polishing main body portion 18 mainly includes an upper surface plate 40, a lower surface plate 60, a sun gear 61, an internal gear 62, a supply pipe 63, an upper plate material 64, the upper rotary shaft 65, and the lower rotary shaft 66.

As shown in FIG. 2, in the polishing apparatus 1, polishing pads 10 are attached to an upper surface of the lower surface plate 60 and a lower surface of the upper surface plate 40. In FIG. 2, the polishing pads 10 are depicted in the form of a sheet. Urethane pads made of urethane resin foam can be used as the polishing pads 10, for example.

[0023] A carrier 30 having holding holes for holding a disk-shaped glass substrate G when main surfaces of the disk-shaped glass substrate G, which is a polishing target, are subjected to polishing processing with the glass substrate G sandwiched between two surface plates is disposed on the upper surface of the lower surface plate 60 and the lower surface of the upper surface plate 40. Although one carrier 30 is depicted in FIG. 2, a plurality of carriers 30 are used. Specifically, the carrier 30 has a tooth portion 31 that is provided on an outer circumferential portion and engages with the sun gear 61 and the internal gear 62, and one or more holding holes 32 for accommodating and holding the glass substrates G. The sun gear 61, the internal gear 62 provided on the outer edge and the disk-shaped carrier 30, as a whole, constitute a planetary gear mechanism centered on a rotary central shaft O of the upper rotary shaft 65 and the lower rotary shaft 66. The disk-shaped carrier 30 engages with the sun gear 61 on the inner circumferential side, engages with the internal gear 62 on the outer circumferential side, accommodates and holds one or more glass substrates G (workpieces). On the lower surface plate 60, the carrier 30 revolves while rotating as a planet gear, and the glass substrates G and the lower surface plate 60 are moved relative to each other. For example, if the sun gear 61 rotates in the CCW (counterclockwise) direction, the carrier 30 rotates in the CW (clockwise) direction, and the internal gear 62 rotates in the CCW direction. As a result, the

lower surface plate 60 and the glass substrates G move relative to each other. Similarly, the glass substrates G and the upper surface plate 40 may be moved relative to each other.

[0024] During the operation of the above-described relative movement, the upper surface plate 40 is pressed against the glass substrates G (that is, in a vertical direction) held by the carrier 30 at a predetermined pressure, and accordingly the polishing pads 10 are pressed against the glass substrates G. Also, during polishing, the polishing slurry is supplied by a pump (not shown) from a supplying tank (not shown) or via a plurality of supply pipes 63 between the glass substrates G and the polishing pads 10. The supply pipes 63 extend to the upper surface plate 40 through the upper plate material 64. The polishing slurry is a liquid in which polishing abrasive particles of colloidal silica are dispersed in an aqueous solution.

[0025] The lower rotary shaft 66 connected to a driving motor (not shown) is fixed to the lower surface plate 60. The upper rotary shaft 65 connected to a driving motor (not shown) is fixed to the upper surface plate 40. Therefore, the upper surface plate 40 and the lower surface plate 60 can freely rotate.

[0026] Aluminosilicate glass is used as the glass substrates G, which are polishing targets, for example. Aluminosilicate glass contains  $\text{SiO}_2$  and  $\text{Al}_2\text{O}_3$  as components.

The polishing slurry used in such a polishing apparatus 1 contains colloidal silica as polishing abrasive particles, and are produced as follows. Specifically, an original polishing slurry containing colloidal silica, which serves as the basis of the polishing slurry, is adjusted to an acid state. Thereafter, large deposits and gel-like substances of silica that are generated in the original polishing slurry are removed by filter processing. Doing this can reduce the amount of dissolved silica in the original polishing slurry. That is, the polishing slurry used in the polishing apparatus of the present embodiment is obtained by subjecting an alkaline original polishing slurry having a relatively high concentration of dissolved silica to dissolved silica reduction processing before the processing for polishing glass substrates. The concentration of dissolved silica in the original polishing slurry is at least 0.03 mass%, for example. The inventor

found that the original polishing slurry containing colloidal silica contains a large amount of dissolved silica in an alkaline state, whereas in an acid state, this original polishing slurry contains a relatively small amount of dissolved silica. In view of this, before being used in the polishing processing, a polishing slurry is produced by reducing the amount of dissolved silica included in the original polishing slurry in advance and removing deposits of dissolved silica and silica gel-like substances through filter processing, and thus it is possible to suppress the deposition of silica from the dissolved silica on the polishing pads or main surfaces of the glass substrates G during polishing. From the viewpoint of dispersibility, the original polishing slurry containing colloidal silica is usually stored under alkaline conditions having a pH of 8 to 12, and thus the pH is adjusted from alkaline to acidic conditions when used for polishing.

[0027] In particular, it is preferable that in a range of pH 1 to 5, the concentration of dissolved silica stably maintains a low level in a range of not more than 0.02 mass%. Note that the concentration of dissolved silica at this time is at least 0.005 mass%. Thus, the original polishing slurry adjusted to an acid state having a pH of 1 to 5 is preferable because the deposition of silica during polishing is stably suppressed. In particular, in order to not increase the roughness of the main surfaces of the glass substrates G, the pH is preferably at least 2, and from a point of cleanability, the pH is preferably not more than 4. Note that in an alkaline state having a pH of at least 10, for example, the concentration of dissolved silica is at least 0.03 mass%. If the pH is at least 10, the concentration of dissolved silica suddenly increases. Therefore, it is preferable to adjust an alkaline original polishing slurry having a pH of at least 10 to acidic because the concentration of dissolved silica can significantly decrease and a larger amount of deposits and gel-like substances of silica can be removed. Also, a difference in pH before and after the pH is adjusted from alkaline to acidic is preferably set to at least 5, and is more preferably set to at least 6. The larger this difference in pH is, the more the deposits and gel-like substances of silica at the time of polishing can be reduced and the more the extraneous matter to the substrate surfaces after polishing can be reduced.

The above-described dissolved silica means silica components other than the silica components present in the polishing slurry as solid particles. Specifically, the dissolved silica indicates silica components present in a dispersion medium that passes through a separation membrane of a separation membrane-attached centrifuge tube and moves to a lower portion of the centrifuge tube when the polishing slurry is subjected to centrifugation processing at a centrifugal force of 4500 G for 90 minutes, the separation membrane having a molecular weight cut off of 10000, and it is inferred that the dissolved silica corresponds to silica oligomer, for example.

The concentration of dissolved silica can be measured with the following method, for example. The polishing slurry is subjected to centrifugation processing using a centrifugal separator to which the separation membrane-attached centrifuge tube (separation membrane molecular weight cut off is 10000) is attached, so as to be separated into a solution component containing dissolved silica and a solid component containing silica particles and the like. Thereafter, with regard to the collected solution component, the amount of dissolved silica is quantitated with a molybdenum reaction and the molecular weight is measured by GPC (gel-permeation chromatography).

[0028] An inorganic acid such as sulfuric acid or nitric acid or an organic acid such as citric acid or tartaric acid can be used to adjust a solution of colloidal silica to an acid state.

The colloidal silica of the present embodiment used in the polishing processing is preferably obtained by heating active silicic acid that is obtained by ion-exchanging an aqueous solution of sodium silicate with a cation exchange resin, because the effect of the dissolved silica reduction processing is significantly exhibited. Although the solution of colloidal silica obtained with this method is obtained at low cost, the solution thereof contains a large amount of dissolved silica because it is an alkaline solution. Therefore, adjusting the solution of colloidal silica to an acid state before polishing processing so as to reduce the amount of dissolved silica and performing the dissolved silica reduction processing for removing deposited silica through filter processing have a great effect of suppressing the deposition of silica from the dissolved silica on the

polishing pads 10 and the main surfaces of the glass substrates G during polishing.

[0029] The average particle diameter (d50) of colloidal silica is preferably 10 to 100 nm because an arithmetic average roughness Ra, which is the surface roughness of the main surfaces of a glass substrate G, is set to not more than 0.2 nm, by polishing the glass substrate G. More preferably, the average particle diameter (d50) is 10 to 40 nm.

Note that it is preferable that, in the filter processing, the original polishing slurry, after being filtered with a depth-type filter, is further filtered with a pleated-type filter. In particular, it is preferable that the filter processing also includes filtering the original polishing slurry with a cation filter after the original polishing slurry is filtered with the depth-type filter, because deposited large silica and gel-like substances are removed and the amount of dissolved silica that dissolves as ions can be reduced. A cation filter can be used for the pleated-type filter.

A depth-type filter refers to a type of filter whose pore size decreases from the outer side toward the inner side (from the upstream side to the downstream side of the polishing slurry flowing through the filter). In other words, the depth-type filter has characteristics such that the pore structure of a filter material is coarse on the entrance side (upstream side) and is fine on the exit side (downstream side), and continuously or gradually becomes finer from the entrance side toward the exit side. With the depth-type filter, large particles of coarse particles are collected near the entrance side, and small particles are collected near the exit side, and thus effective filtration is possible. The shape of the depth-type filter may be a bag type having a bag shape, or a cartridge type having a hollow circular cylindrical shape.

In general, a filter obtained by molding a filter material into a pleated shape to form a cartridge type filter having a hollow circular cylindrical shape can be used as the pleated-type filter used in the present embodiment. Unlike the depth-type filter that collects particles at each portion in the thickness direction, it is said that the filter material for the pleated-type filter has a thin thickness and the filter surface mainly collect particles, and thus in general, the

pleated-type filter is characterized by a high filtration accuracy.

The pore sizes of the depth-type filter and the pleated-type filter are usually expressed as filtration accuracy according which 99% removal is possible, and for example, a pore size 1.0  $\mu\text{m}$  indicates a filter with which 99% of particles having a diameter of 1.0  $\mu\text{m}$  can be removed. From the viewpoint of a reduction in the load for removing coarse particles, the pore size of the depth-type filter is preferably not more than 1.5  $\mu\text{m}$ , and is more preferably not more than 1.0  $\mu\text{m}$ . From the viewpoint of a reduction in coarse particles, the pore size of the pleated-type filter is preferably not more than 1.0  $\mu\text{m}$ , is more preferably not more than 0.8  $\mu\text{m}$ , and is even more preferably not more than 0.5  $\mu\text{m}$ .

The main surfaces on both sides of the glass substrate G are polished by moving the glass substrates 10 and the polishing pads 10 relative to each other while such a polishing slurry is supplied between the glass substrates G pressed by the polishing pads 10 and the polishing pads 10.

[0030] Method for manufacturing glass substrate

A glass substrate on which polishing processing is performed using such colloidal silica is produced by a method for manufacturing a glass substrate described below. In the method for manufacturing a magnetic-disk glass substrate of the present embodiment, processing for molding a glass blank, which is a material for a plate-shaped magnetic-disk glass substrate having a pair of main surfaces, is first performed. Next, processing for rough-grinding this glass blank is performed. After this, shape processing and edge surface polishing processing are performed on the glass blank. Thereafter, precision grinding processing using fixed abrasive particles is performed on the glass substrate obtained from the glass blank. First polishing processing, chemical strengthening processing, and second polishing processing are then performed on the glass substrate. Note that although the above-described processes are performed in the above-described flow in the present embodiment, all of the above-described processes need not be performed and some of these processes may not be performed as appropriate. Hereinafter, each type of processing will be described. Note that the second polishing processing is the target for the processing for polishing the glass substrate G using a polishing slurry containing colloidal silica on which the

above-described dissolved silica reduction processing has been performed.

[0031] (a) Processing for molding glass blank

A press molding method may be used to mold a glass blank, for example. A circular glass blank can be obtained by a press molding method. Moreover, a glass blank can be manufactured using a known manufacturing method such as a downdraw method, a redraw method, a fusion method, or a float method. A disk-shaped glass substrate, which is the basis for a magnetic-disk glass substrate, can be obtained by appropriately performing shape processing on the plate-shaped glass blank produced with these known manufacturing methods.

[0032] (b) Rough grinding processing

In the rough grinding processing, specifically, main surfaces on both sides of the glass blank are ground while the glass blank is held in a holding hole provided in a holding member (carrier) mounted on a known double-sided grinding apparatus. At this time, the above-described carrier 30 may be used. Loose abrasive particles are used as a grinding material, for example. In rough grinding processing, grinding is performed such that the glass blank is brought approximately closer to have a target substrate thickness and a target flatness of the main surfaces. Note that the rough grinding processing is performed in accordance with the dimensional accuracy or the surface roughness of the molded glass blank, and may be omitted in some cases.

[0033] (c) Shape processing

Next, shape processing is performed. In the shape processing, after the glass blank is molded, a circular hole is formed using a known processing method to obtain a disk-shaped glass substrate having the circular hole. Thereafter, chamfering is performed on edge surfaces of the glass substrate. Accordingly, a side wall surface orthogonal to the main surfaces and an inclined surface (interposing surface) that connects the side wall surface and the main surfaces are formed on the edge surface of the glass substrate.

[0034] (d) Edge surface polishing processing

Next, processing for polishing edge surfaces of the glass substrate is performed. The edge surface polishing processing is processing for performing polishing by supplying a polishing liquid containing loose abrasive particles

between a polishing brush and the edge surfaces of the glass substrate and moving the polishing brush and the glass substrate relative to each other. In edge surface polishing, an inner circumferential side edge surface and an outer circumferential side edge surface of the glass substrate are polishing targets, and the inner circumferential side edge surface and the outer circumferential side edge surface are formed into mirror surfaces.

[0035] (e) Precision grinding processing

Next, precision grinding processing is performed on the main surfaces of the glass substrate. Specifically, grinding is performed on the main surfaces of the glass substrate using a known double-sided grinding apparatus. In this case, grinding is performed by providing fixed abrasive particles to surface plates. Specifically, the main surfaces on both sides of the glass substrate are ground while the glass substrate is held in a holding hole provided in a carrier, which is the holding member of the double-sided grinding apparatus.

Although the main surfaces of the glass substrate are ground by bringing grinding surfaces containing the fixed abrasive particles and the main surfaces of the glass substrate into contact with each other in the grinding processing of the present embodiment, grinding using loose abrasive particles may be performed.

[0036] (f) First polishing processing

Next, first polishing processing is performed on the main surfaces of the glass substrate. Specifically, the main surfaces on both sides of the glass substrate are polished while an outer circumferential side edge surface of the glass substrate is held in the holding hole provided in the carrier of the polishing apparatus having a configuration similar to that of the polishing apparatus shown in FIGS. 1 and 2. In the first polishing processing, loose abrasive particles and polishing pads attached to the surface plates are used. First polishing removes cracks and warping remaining on the main surfaces in the case where grinding is performed with fixed abrasive particles, for example, while adjusting the thickness of the glass substrate. In first polishing, it is possible to reduce a surface roughness of the main surfaces, that is, an arithmetic average roughness  $R_a$ , for example, while preventing the shape of the end portions of the main surfaces from excessively recessing or protruding. Note that in the first polishing

processing, colloidal silica is not used as the polishing slurry, and cerium oxideabrasive particles, zirconia abrasive particles, or the like are used, for example. Thus, the polishing slurry on which the dissolved silica reduction processing has been performed is not used in the first polishing processing. Note that although there is no particular limitation on the type of polishing pad, a hard urethane resin foam polisher is used, for example.

#### [0037] (g) Chemical strengthening processing

The glass substrate may be subjected to chemical strengthening as appropriate. A molten liquid obtained by heating potassium nitrate, sodium nitrate, or a mixture thereof, for example, can be used as a chemical strengthening liquid. Then, by immersing the glass substrate in the chemical strengthening liquid, lithium ions and sodium ions in the glass composition in the surface layer of the glass substrate are respectively substituted with sodium ions and potassium ions with relatively large ion radii in the chemical strengthening liquid, and a compressive stress layer is formed in a surface layer portion, as a result of which the glass substrate is strengthened.

Although the time at which the chemical strengthening processing is performed is determined as appropriate, the polishing processing is particularly preferably performed after the chemical strengthening processing, because the surface can be smoothed and foreign matter adhering to the surfaces of the glass substrates can be removed by the chemical strengthening processing. Also, the chemical strengthening processing is performed as needed, and need not be performed.

#### [0038] (h) Second polishing (mirror surface polishing) processing

Next, second polishing is performed on the glass substrate that has undergone the chemical strengthening processing. Second polishing processing is for mirror-polishing the main surfaces. A double-sided polishing apparatus shown in FIGS. 1 and 2 is also used in second polishing. Doing so makes it possible to reduce the roughness of the main surfaces while preventing the shape of end portions of the main surfaces from excessively recessing or protruding while finely adjusting the thickness of the glass substrate G. Accordingly, the arithmetic average roughness  $R_a$  of the main surfaces of the glass substrate G can be set to

not more than 0.2 nm, and is more preferably set to not more than 0.15 nm. At this time, the maximum roughness  $R_{\max}$  is preferably not more than 2.0 nm. In the second polishing processing, the hardness of a resin polisher of the polishing pad is softer than in the first polishing processing. It is preferable that a polishing  
5 pad used in the second polishing processing has an Asker C hardness of not less than 60 and not more than 80.

[0039] The colloidal silica on which the above-described dissolved silica reduction processing has been performed is used as the loose abrasive particles used in the second polishing processing. That is, a polishing slurry containing colloidal silica  
10 as the polishing abrasive particles is used in the second polishing processing. This polishing slurry contains dissolved silica in a small amount due to the dissolved silica reduction processing being performed, and thus the deposition of a portion of the dissolved silica can be suppressed during polishing. Therefore, it is possible to reduce extraneous matter, which has been a conventional problem, that causes  
15 defects on the main surfaces of the glass substrate.

[0040] After being used to polish the main surfaces of the glass substrate, such a polishing slurry may be collected and used to polish main surfaces of another glass substrate. At this time, it is preferable that after the polishing slurry has been repeatedly used in the polishing processing, the above-described dissolved silica  
20 reduction processing is performed on the polishing slurry containing colloidal silica as polishing abrasive particles, and then is used to polish the other glass substrate.

If the polishing slurry is used while being circulated, it is preferable to use the above-described dissolved silica reduction processing. If the polishing  
25 processing is performed repeatedly, a portion of polishing abrasive particles dissolve due to frictional heat or the like resulting from sliding between the polishing pads and the glass substrate, and the concentration of dissolved silica increases in some cases. In such a case, sometimes, silica aggregates or gel-like substances newly form from the dissolved silica in the polishing slurry. Thus, if  
30 the polishing slurry is used repeatedly, the dissolved silica reduction processing as in the present embodiment is preferably performed before the start of polishing.

[0041] A adherent layer, a soft magnetic layer, a base layer, a perpendicular magnetic recording layer, a carbon protective layer, and a lubricant layer, for example, are formed in order on the main surfaces of a magnetic-disk glass substrate produced in this manner. Accordingly, a magnetic disk is produced. The carbon protective layer is for preventing degradation of the magnetic recording layer caused by contact with the magnetic head, and the protective layer is composed of hydrogenated carbon, for example, and yields wear resistance. Also, an alcohol-modified perfluoropolyether liquid lubricant is used as the lubricant layer, for example.

#### 10 [0042] Experiment Example

In order to confirm the effects of the present embodiment, polishing slurries were produced by variously changing whether or not the processing for reducing silica dissolved in an original polishing slurry before a polishing slurry used in the second polishing processing is produced is performed, and changing the content of filter processing in the dissolved silica reduction processing, and glass substrates were produced by performing the second polishing processing using this polishing slurry. Furthermore, magnetic disks were produced using these glass substrates.

First, after an aluminosilicate glass substrate G was subjected to processes up to (g) the chemical strengthening processing described above, the second polishing processing was performed using a polishing slurry obtained by variously changing whether or not the dissolved silica reduction processing is performed and changing the content of the filter processing.

The polishing pads used in each example below are polishing pads (polyurethane resin foam having an Asker C hardness of 72) with a soft polisher (suede) as the polisher. This second polishing processing is mirror-surface polishing processing for finishing main surfaces of a flat glass substrate G into smooth mirror surfaces having a surface roughness  $R_{\max}$  of not more than about 2 nm while maintaining the flat main surfaces of the glass substrate G obtained in the above-described first polishing processing. Note that in the second polishing processing, the load was set to 100 g/cm<sup>2</sup>, and the polishing time was set to 10 minutes. After undergoing the above-described second polishing processing, the

glass substrate G was immersed in cleaning tanks of a neutral detergent, pure water, pure water, and IPA in order, was subjected to ultrasound cleaning, and then was subjected to steam drying with IPA.

[0043] Working Example 1

5           A polishing slurry obtained by preparing an original polishing slurry obtained by dispersing a polishing agent of colloidal silica (average particle diameter (d50) of 15 nm) in water at 15 wt% (pH 10), adjusting the pH of this original polishing slurry to acidic (pH 4) through addition of sulfuric acid for pH adjustment, and then subjecting the adjusted polishing slurry to filter processing  
10 with a depth-type filter and a pleated-type filter in this order, was used as the polishing slurry. A filter having a pore size of 1  $\mu\text{m}$  was used as the depth-type filter. A filter having a pore size of 0.5  $\mu\text{m}$  was used as the pleated-type filter.

[0044] Working Example 2

          In Working Example 2, second polishing was performed using a polishing  
15 slurry obtained by adjusting the pH of an original polishing slurry similar to Working Example 1 to acidic (pH 4) through addition of sulfuric acid for pH adjustment, and then subjecting the adjusted polishing slurry to filter processing using a depth-type filter having a pore size of 1  $\mu\text{m}$ , a cationpleated-type filter, and then the above-described pleated-type filter. The cationpleated-type filter is  
20 obtained by subjecting a pleated-type filter having a pore size of 1  $\mu\text{m}$  to cationization processing.

[0045] Working Example 3

          In Working Example 3, processing that is the same as in Working Example 1 was performed except that the original polishing slurry was adjusted  
25 by adding sulfuric acid for pH adjustment to be an acidic slurry having a pH of 5.

[0046] Working Example 4

          In Working Example 4, processing that is the same as in Working Example 1 was performed except that the original polishing slurry was adjusted by adding sulfuric acid for pH adjustment to be an acidic slurry having a pH of 2.

30 [0047] Working Example 5

          In Working Example 5, processing that is the same as in Working Example 1 was performed except that the original polishing slurry was adjusted

by adding sulfuric acid for pH adjustment to be an acidic slurry having a pH of 1.

[0048] Working Example 6

In Working Example 6, processing that is the same as in Working Example 2 was performed except that the original polishing slurry was adjusted  
5 by adding sulfuric acid for pH adjustment to be an acidic slurry having a pH of 5.

[0049] Working Example 7

In Working Example 7, processing that is the same as in Working Example 2 was performed except that the original polishing slurry was adjusted by adding sulfuric acid for pH adjustment to be an acidic slurry having a pH of 2.

10 [0050] Working Example 8

In Working Example 8, processing that is the same as in Working Example 1 was performed except that a polishing slurry on which filter processing was performed using a pleated-type filter and a depth-type filter in this order was used as the polishing slurry, and a filter having a pore size of 1  $\mu\text{m}$   
15 was used as the pleated-type filter, and a filter having a pore size of 0.5  $\mu\text{m}$  was used as the depth-type filter.

[0051] Comparative Example 1

In Comparative Example 1, filter processing was not performed on an original polishing slurry similar to Working Example 1 before polishing, and  
20 similarly to Working Example 1, the original polishing slurry was adjusted to acidic (pH 4), and the adjusted slurry was used in polishing.

[0052] Comparative Example 2

In Comparative Example 2, after an original polishing slurry similar to Working Example 1 was subjected to filter processing using the above-described  
25 depth-type filter and the above-described pleated-type filter in this order, similarly to Working Example 1, the resulting slurry was adjusted to acidic (pH 4), and then the adjusted slurry was used in polishing.

[0053] Comparative Example 3

In Comparative Example 3, an original polishing slurry similar to  
30 Working Example 1 was subjected to filter processing (filtering) using a depth-type filter (having a pore size of 1  $\mu\text{m}$ ), the above-described cationpleated-type filter (having a pore size of 1  $\mu\text{m}$ ) that has been subjected to

cationization processing, and then a pleated-type filter (having a pore size of 0.5  $\mu\text{m}$ ). The polishing slurry on which this filter processing was performed was dispersed in water at 15 wt%, similarly to Working Example 1, was adjusted to acidic (pH 4), and then was used in polishing.

5 [0054] The glass substrates obtained in the above-described examples were observed with an OSA (Optical surface analyzer), points of defects were analyzed in detail with a SEM (scanning electron microscope)/EDX (energy dispersive X-ray spectrometry).

[0055] In Working Example 1, the number of defects of silica aggregates and  
10 gel-like substances of the defects detected on the main surfaces of a glass substrate was 36 points. Hereinafter, similarly, in the order starting from Working Examples 2 to 8, Comparative Example 1, Comparative Example 2, and Comparative Example 3, 20, 44, 29, 24, 24, 10, 38, 98, 71, and 62 points of silica aggregates and gel-like substances were detected as defects. Table 1 below shows  
15 the results thereof. In the table below, the depth-type filter is called depth filter, a pleated-type filter is called pleated filter, and a cationpleated-type filter is called cationpleated filter.

[0056] [Table 1]

|             | Order of filtering and pH adjustment         | Filtering conditions                                                                                               | Number of detected defects |
|-------------|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------|----------------------------|
| Work. Ex. 1 | pH adjustment (pH 4)→filtering               | 1: 1 $\mu\text{m}$ depth filter<br>2: 0.5 $\mu\text{m}$ pleated filter                                             | 36                         |
| Work. Ex. 2 | pH adjustment (pH 4)→filtering               | 1: 1 $\mu\text{m}$ depth filter<br>2: 1 $\mu\text{m}$ cation pleated filter<br>3: 0.5 $\mu\text{m}$ pleated filter | 20                         |
| Work. Ex. 3 | pH adjustment (pH 5)→filtering               | 1: 1 $\mu\text{m}$ depth filter<br>2: 0.5 $\mu\text{m}$ pleated filter                                             | 44                         |
| Work. Ex. 4 | pH adjustment (pH 2)→filtering               | 1: 1 $\mu\text{m}$ depth filter<br>2: 0.5 $\mu\text{m}$ pleated filter                                             | 29                         |
| Work. Ex. 5 | pH adjustment (pH 1)→filtering               | 1: 1 $\mu\text{m}$ depth filter<br>2: 0.5 $\mu\text{m}$ pleated filter                                             | 24                         |
| Work. Ex. 6 | pH adjustment (pH 5)→filtering               | 1: 1 $\mu\text{m}$ depth filter<br>2: 1 $\mu\text{m}$ cation pleated filter<br>3: 0.5 $\mu\text{m}$ pleated filter | 24                         |
| Work. Ex. 7 | pH adjustment (pH 2)→filtering               | 1: 1 $\mu\text{m}$ depth filter<br>2: 1 $\mu\text{m}$ cation pleated filter<br>3: 0.5 $\mu\text{m}$ pleated filter | 10                         |
| Work. Ex. 8 | pH adjustment (pH 4)→filtering               | 1: 1 $\mu\text{m}$ pleated filter<br>2: 0.5 $\mu\text{m}$ depth filter                                             | 38                         |
| Comp. Ex. 1 | pH adjustment (pH 4) alone<br>(no filtering) | no filtering                                                                                                       | 98                         |
| Comp. Ex. 2 | filtering → pH adjustment<br>(pH 4)          | 1: 1 $\mu\text{m}$ depth filter<br>2: 0.5 $\mu\text{m}$ pleated filter                                             | 71                         |
| Comp. Ex. 3 | filtering → pH adjustment<br>(pH 4)          | 1: 1 $\mu\text{m}$ depth filter<br>2: 1 $\mu\text{m}$ cation pleated filter<br>3: 0.5 $\mu\text{m}$ pleated filter | 62                         |

[0057] According to the comparison results of evaluations of Working Example 1 and Comparative Example 2 and comparison results of evaluations of Working Example 2 and Comparative Example 3, it was found that a polishing slurry obtained by performing filter processing after the original polishing slurry has been adjusted from an alkaline state to an acid state is effective in avoiding extraneous matter of silica aggregates and gel-like substances to the main surfaces of the glass substrates.

Also, according to the comparison results of evaluations of Working Example 1 and Comparative Example 1, it was found that even if the polishing slurry is adjusted to an acid state so as to reduce the dissolved silica, if filter processing is not performed, it is not possible to suppress extraneous matter of silica aggregates and gel-like substances to the main surfaces of the glass

substrates.

According to the comparison results of evaluations of Working Example 1 and Working Example 2, it was also found that it is also preferable to include filtering the polishing slurry with a cation filter after the polishing slurry has  
5 been filtered with the depth-type filter.

Furthermore, according to the comparison results of evaluations of Working Examples 3 to 5, and the comparison results of evaluations of Working Examples 6 and 7, the pH is preferably set to not more than 5, and is more preferably set to not more than 2, because the lower the pH is, the more the  
10 extraneous matter of silica aggregates and gel-like substances to the main surfaces of the glass substrates is suppressed.

Also, according to the comparison results of evaluations of Working Example 1 and Working Example 8, it was found that it is preferable to use the depth-type filter and the pleated-type filter in this order in the filter  
15 processing. Note that compared to Working Example 1, it was observed that the used filter was easily clogged in Working Example 8.

Accordingly, the effects of the present embodiment are clear.

[0058] As described above, although a method for manufacturing a magnetic-disk glass substrate and a method for manufacturing a magnetic disk  
20 according to 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 without departing from the gist of the present invention.

25 [Description of Reference Numerals]

|        |    |                             |
|--------|----|-----------------------------|
| [0059] | 1  | Polishing apparatus         |
|        | 10 | Polishing pad               |
|        | 12 | Upper support table         |
|        | 14 | Lower support table         |
| 30     | 18 | Polishing main body portion |
|        | 30 | Carrier                     |
|        | 31 | Tooth portion               |

|    |    |                      |
|----|----|----------------------|
|    | 32 | Holding hole         |
|    | 40 | Upper surface plate  |
|    | 60 | Lower surface plate  |
|    | 61 | Sun gear             |
| 5  | 62 | Internal gear        |
|    | 63 | Supply pipe          |
|    | 64 | Upper plate material |
|    | 65 | Upper rotary shaft   |
|    | 66 | Lower rotary shaft   |
| 10 |    |                      |

## CLAIMS

1. A method for manufacturing a magnetic-disk glass substrate, comprising:  
a step of polishing main surfaces on both sides of a glass substrate by  
pressing polishing pads against the main surfaces and moving the main  
5 surfaces and the polishing pads relative to each other while supplying a  
polishing slurry containing colloidal silica as polishing abrasive particles  
between the glass substrate and the polishing pads; and  
a step of producing the polishing slurry by, before the main surfaces are  
polished, adjusting an original polishing slurry that serves as a basis of the  
10 polishing slurry to be used in the polishing processing to an acid state and  
removing, through filter processing, a silica deposit from the original  
polishing slurry generated by adjusting the original polishing slurry to the  
acid state.
2. The method for manufacturing a magnetic-disk glass substrate according  
15 to claim 1, wherein  
the original polishing slurry is an alkaline slurry.
3. The method for manufacturing a magnetic-disk glass substrate according  
to claim 1 or 2, wherein  
an original polishing slurry after adjustment to the acid state has a pH of 1  
20 to 5.
4. The method for manufacturing a magnetic-disk glass substrate according  
to any one of claims 1 to 3, wherein  
a concentration of dissolved silica in the polishing slurry is not more than  
0.02 mass%.

5. The method for manufacturing a magnetic-disk glass substrate according to any one of claims 1 to 4, wherein  
the colloidal silica is obtained by heating active silicic acid obtained by ion  
exchanging an aqueous solution of sodium silicate with a cation exchange  
resin.  
5
6. The method for manufacturing a magnetic-disk glass substrate according to any one of claims 1 to 5, wherein  
the polishing slurry, after being used to polish the main surfaces of the  
glass substrate, is collected and used to polish main surfaces of another  
glass substrate.  
10
7. The method for manufacturing a magnetic-disk glass substrate according to any one of claims 1 to 6, wherein  
the colloidal silica has an average particle diameter of 10 to 100 nm.
8. The method for manufacturing a magnetic-disk glass substrate according to any one of claims 1 to 7, wherein  
the filter processing includes filtering with a depth-type filter and filtering  
with a cation-type filter after the filtration with the depth-type filter.  
15
9. A method for manufacturing a magnetic disk, in which at least a magnetic  
layer is formed on the main surfaces of the magnetic-disk glass substrate  
produced with the manufacturing method according to any one of claims 1  
to 8.  
20