METHOD OF MANUFACTURING A GLASS SUBSTRATE FOR A MAGNETIC DISK

Technical Field:

This invention relates to a method of manufacturing a glass substrate for a magnetic disk adapted to be mounted in a hard disk drive device.

Background Art:

In recent years, hard disk drive devices (HDD devices) have been requiring magnetic disks that are adaptable to higher-density recording and still are lower priced. For achieving higher-density recording of a magnetic disk, it is important to reduce the flying height of a magnetic head. Since the flying height of a magnetic head is correlated with the surface roughness or waviness of the surface of a magnetic disk, an attempt has been made to further reduce the surface roughness of a magnetic-disk substrate. Further, for achieving higher-density recording of a magnetic disk, it is necessary to reduce defects such as the residue of polishing abrasive particles on the surface of a magnetic-disk substrate.

Hitherto, glass substrates have been used as magnetic-disk substrates for the reason that mechanical durability and high smoothness can be obtained and so on. As a method of smoothing the surface of a glass substrate, there is known a polishing method using a polisher containing colloidal silica abrasive particles (Japanese Unexamined Patent Application Publication (JP-A) No. 2003-173518).

Disclosure of the Invention:

In a polishing process using a polisher containing colloidal silica abrasive particles, the pH control of the polishing solution and the particle size control of the abrasive particles are known as means for reducing the level of surface roughness. In the pH control, for example, when the solution property of the polisher is in an alkaline region being a stable region of silica, since leaching (ion release) on the glass surface does not occur, an increase in surface roughness in a subsequent cleaning process is suppressed so that the surface roughness can be set to a low level, but it is not possible to obtain an excellent polishing rate. Conversely, when the solution property of the polisher is in an acidic region being a metastable region of silica, an excellent polishing rate is obtained because of the occurrence of leaching on the glass substrate surface and an increase in secondary particle size of the colloidal silica abrasive particles due to approach of the absolute value of the zeta potential of the abrasive particles to zero and, further, since the absolute value of the zeta potential of the glass substrate surface also approaches zero, high cleaning performance is obtained. However, since the leaching is large to cause a leaching layer to reach deep, the surface roughness significantly increases due to alkali etching in the cleaning process so that the surface roughness cannot be set to a low level. On the other hand, when the solution property of the polisher is in a neutral region, although it is possible to achieve a surface roughness equivalent to that in the alkaline region because the leaching does not occur, there remains a problem that not only a high polishing rate like that in the acidic region is not obtained, but also high cleaning performance is not obtained due to a large absolute value of the zeta potential of the glass substrate surface and thus it is not possible to achieve required surface defect quality.

As described above, with the polisher having any of the solution

properties, it is not possible to simultaneously realize a low-level surface roughness, a low-level surface defect, and a fast polishing rate.

In the particle size control of the abrasive particles, it is known that, by reducing the particle size of the colloidal silica abrasive particles, the surface roughness can be set to a low level, while, the polishing rate decreases. However, when the solution property of the polisher is in the acidic region, not only is it difficult to achieve a currently required surface roughness only by reducing the particle size of the colloidal silica abrasive particles, but also the productivity is largely degraded. Further, when the solution property of the polisher is in the alkaline region or the neutral region, there is a problem that the polishing rate is extremely low and, as described above, the surface defect quality of the glass substrate cannot be achieved.

This invention has been made in view of the above circumstances and has an object to provide a method that can simultaneously realize a low-level surface roughness, a low-level surface defect, and a fast polishing rate in the manufacture of a magnetic-disk glass substrate.

According to this invention, there is provided a method of manufacturing a magnetic-disk glass substrate, the method including a step of polishing a main surface of a glass substrate using a polisher, characterized in that the polisher has a pH of 4 to 6 and contains polishing particles, a dispersion medium serving to disperse the polishing particles, and an additive serving to increase an electrolyte concentration in the polisher without changing the pH of the polisher, thereby performing polishing using the polisher.

According to this invention, there is provided a method of manufacturing a magnetic-disk glass substrate, the method including a step of polishing a main surface of a glass substrate using a polisher, characterized in that the polisher has a pH of 4 to 6 and contains polishing particles having a predetermined zeta potential, a dispersion medium serving to disperse the polishing particles, and

an additive serving to cause the zeta potential to approach zero at the pH, thereby performing polishing using the polisher.

According to these methods, since the additive serving to increase the electrolyte concentration in the polisher without changing the pH of the polisher (the additive serving to cause the zeta potential to approach zero at the pH of the polisher) is added to the polisher, it is possible to simultaneously realize a low-level surface roughness, a low-level surface defect, and a fast polishing rate in the manufacture of a magnetic-disk glass substrate.

Preferably, in the method of manufacturing a magnetic-disk glass substrate according to this invention, the polisher is colloidal silica and the additive is at least one selected from the group consisting of a sulfuric acid compound, a phosphoric acid compound, and a nitric acid compound.

Preferably, in the method of manufacturing a magnetic-disk glass substrate according to this invention, an addition amount of the additive is 0.1wt% to 5.0wt% relative to the total weight of the polisher.

A magnetic disk according to this invention comprises the magnetic-disk glass substrate obtained by the aforementioned method of manufacturing a magnetic-disk glass substrate and a magnetic layer on the magnetic-disk glass substrate directly or through another layer.

A polisher according to this invention is characterized in that the polisher is used in polishing a main surface of a glass substrate, and the polisher has a pH of 4 to 6 and contains polishing particles, a dispersion medium serving to disperse the polishing particles, and an additive serving to increase an electrolyte concentration in the polisher without changing the pH of the polisher.

According to this invention, in a method of manufacturing a magnetic-disk glass substrate, the method including a step of polishing a main surface of a glass substrate using a polisher, the polisher has a pH of 4 to 6 and

comprises polishing particles, a dispersion medium serving to disperse the polishing particles, and an additive serving to increase an electrolyte concentration in the polisher without changing the pH of the polisher, so that it is possible to simultaneously realize a low-level surface roughness, a low-level surface defect, and a fast polishing rate in the manufacture of a magnetic-disk glass substrate.

Brief Description of the Drawings:

Fig. 1 is a diagram showing the relationship between the zeta potential and the pH in a polishing process.

Fig. 2 is a diagram showing the relationship between the polishing rate and the pH.

Fig. 3 is a diagram showing the relationship between the surface roughness Ra before cleaning and the pH.

Fig. 4 is a diagram showing the relationship between the surface roughness Ra after cleaning and the pH.

Fig. 5 is a diagram showing the relationship between the number of surface defects and the pH.

Description of the Exemplary Embodiment:

As described before, in the glass substrate polishing process, when the solution property of the polisher is in the acidic region, although the polishing rate becomes fast, the leaching is large enough to cause the surface roughness to significantly increase due to alkali etching in the cleaning process and thus the surface roughness cannot be set to a low level. On the other hand, when the solution property of the polisher is in the alkaline region, since the leaching does not occur, the surface roughness can be set to a low level, but the polishing rate decreases. Further, when the solution property of the polisher is

in the neutral region, although it is possible to achieve a surface roughness equivalent to that in the alkaline region because the leaching does not occur, a high polishing rate like that in the acidic region is not obtained and, due to a large absolute value of the zeta potential of the glass substrate surface, high cleaning performance is not obtained and thus it is not possible to achieve required surface defect quality.

As shown in Fig. 1, it is known that the zeta potential of colloidal silica (SiO_2) being a general polisher has an isoelectric point around pH 2 of a solution thereof and then the absolute value of the zeta potential increases toward the minus side as the pH shifts toward the alkaline region side (characteristic curve on the left side in Fig. 1). Therefore, around pH 2, aggregation of colloidal silica abrasive particles proceeds most and thus the secondary particle size thereof becomes maximum. By combination of the magnitude of this secondary particle size and the leaching due to the pH of the polisher, a high polishing rate is obtained in the acidic region. Further, the behavior of the zeta potential, due to the pH, of a glass substrate itself is similar to that of the zeta potential of colloidal silica so that as the solution property of the polisher approaches pH 2, the zeta potential of the glass substrate also approaches zero. Therefore, foreign substances having plus-side potentials are reluctant to adhere to the glass substrate surface and, as a result, high cleanness is obtained.

On the other hand, as the reason that the surface roughness of the glass substrate is degraded by the use of the polisher in the acidic region, there is cited a factor due to combination with cleaning. According to the results of studies by the present inventors, it has been found that the surface roughness is degraded by applying an alkaline chemical solution treatment after an acidic chemical solution treatment and the increase width of the surface roughness in this event depends on the depth of a leaching layer generated in the acidic

chemical solution treatment. That is, as the depth of the leaching layer increases, the increase width of the surface roughness increases due to the subsequent alkaline chemical solution treatment.

The present inventors, paying attention to such a phenomenon, have found that a polisher capable of simultaneously achieving a high polishing rate, high cleanness, and a low surface roughness is required to have properties of 1) causing the zeta potential of polishing particles to approach an isoelectric point for increasing the secondary particle size, 2) causing the occurrence of a leaching effect, and 3) reducing the thickness of a leaching layer. In this case, the solution property of the polisher is preferably in the acidic region in terms of causing the occurrence of the leaching in polishing, but if the acid is strong, the leaching layer increases in thickness. On the other hand, the leaching does not occur when the solution property of the polisher is neutral or alkaline. Therefore, for forming a thin leaching layer in a glass substrate, it is necessary that the solution property of the polisher be weak acid, for example, pH 4 to 6. This makes it possible to realize a low surface roughness.

On the other hand, when the solution property of the polisher is set in the weak acidic region as described above, the polishing rate becomes lower than that in the acidic region. As described above, the aggregation proceeds most at the isoelectric point of the zeta potential of the polishing particles so that the secondary particle size becomes maximum to thereby increase the polishing rate. Therefore, if the isoelectric point of the zeta potential of the polishing particles is obtained when the solution property of the polisher is weak acid, a high polishing rate and high cleanness can be realized in the state where the above low surface roughness is realized. As a result of assiduous studies in view of this point, the present inventors have found that it is possible to cause the zeta potential of the polishing particles and the glass substrate to approach zero by adding to the polisher an additive serving to increase the

electrolyte concentration without changing the pH, and have reached this invention.

That is, the gist of this invention is a method of manufacturing a magnetic-disk glass substrate, the method including a process of polishing a main surface of a glass substrate using a polisher, wherein the polisher has a pH of 4 to 6 and comprises polishing particles, a dispersion medium serving to disperse the polishing particles, and an additive serving to increase an electrolyte concentration in the polisher without changing the pH of the polisher, thereby simultaneously realizing a low-level surface roughness, a low-level surface defect, and a fast polishing rate.

The additive serving to increase the electrolyte concentration without changing the pH as described above is an additive serving to cause the zeta potential of the polishing particles and the glass substrate to approach zero at a specific pH. By adding such an additive to the polisher, it is possible to shift the characteristic curve between the zeta potential and the pH as shown in Fig. 1 (herein, shift the isoelectric point toward the weak acid side).

In this invention, a polisher used in a final polishing process (second polishing process) of the main surface of a glass substrate comprises polishing particles, a dispersion medium serving to disperse the polishing particles, and an additive serving to increase the electrolyte concentration in the polisher without changing the pH of the polisher (an additive serving to cause the zeta potential to approach zero at a specific pH).

As the additive serving to increase the electrolyte concentration in the polisher without changing the pH of the polisher, there can be cited, for example, a sulfuric acid compound such as K_2SO_4 or Na_2SO_4, a phosphoric acid compound such as K_3PO_4 or Na_3PO_4, or a nitric acid compound such as Na_2NO_4. As the polishing particles, there can be cited silica particles, ceria particles, or the like. Further, as the dispersion medium, there can be cited

water or the like. For example, in this invention, there is cited colloidal silica added with Na_2SO_4 as an additive. Such colloidal silica has an isoelectric point around pH 4, while the isoelectric point normally appears around pH 2.

The addition amount of such an additive is preferably 0.1wt% to 5.0wt% relative to the total weight of the polisher in consideration of the balance between effect and cost, and so on.

In the manufacture of a glass substrate, processes, i.e. (1) a shaping process and a first lapping process, (2) an end portion shaping process (a coring process for forming a hole portion and a chamfering process (chamfered face forming process) for forming chamfered faces at end portions (an outer peripheral end portion and an inner peripheral end portion)), (3) an end face polishing process (an outer peripheral end portion and an inner peripheral end portion), (4) a second lapping process, (5) main surface first polishing, (6) polishing cleaning, (7) main surface second polishing, (8) chemical strengthening, and (9) polishing (final) cleaning, are carried out in this order. In this invention, use is made, in the main surface second polishing, of a polisher comprising polishing particles, a dispersion medium serving to disperse the polishing particles, and an additive serving to increase the electrolyte concentration in the polisher without changing the pH of the polisher (an additive serving to cause the zeta potential to approach zero at a specific pH).

In such second polishing, since the polisher is weak acid (pH 4 to 6), a very thin leaching layer is formed at the surface of a glass substrate being a workpiece. Further, since the additive serving to increase the electrolyte concentration is added to the polisher, an isoelectric point of the polishing particles is shifted so that aggregation of the polishing particles proceeds even if the solution property is weak acid, thereby increasing the secondary particle size thereof. With these actions, a high polishing rate is obtained. Further, since the zeta potential of the glass substrate surface also approaches an

isoelectric point, foreign substances having plus potentials are reluctant to adhere to the glass substrate surface and, therefore, high cleanness is obtained. Further, since the solution property of the polisher is weak acid, although the leaching layer is formed at the glass substrate surface, the thickness thereof is extremely thin. As a result, the etching amount during an alkaline chemical solution treatment in a subsequent cleaning process is suppressed to be very small and thus an increase in surface roughness of the substrate is suppressed.

Next, a description will be given of Examples carried out for clarifying the effect of this invention.

(Example 1)

(1) Rough Grinding Process

At first, molten glass was subjected to direct pressing using upper, lower, and drum molds, thereby obtaining a disk-shaped glass substrate having a diameter of 66mmφ and a thickness of 1.2mm and made of aluminosilicate glass. In this case, other than the direct pressing, a disk-shaped glass substrate may be obtained by cutting it out, using a grindstone, from a sheet glass formed by a downdraw method or a float method. As the aluminosilicate glass, use was made of a substrate glass for chemical strengthening which contains, as main components, SiO_2 : 58 to 75wt%, Al_2O_3 : 5 to 23wt%, LiO_2 : 3 to 10wt%, and Na_2O : 4 to 13wt%.

Then, a grinding process was applied to the glass substrate. The grinding process is for the purpose of improving the size accuracy and the shape accuracy. The grinding process was performed by using a double-side grinding machine and setting the particle size of abrasive particles to #400. Specifically, using alumina abrasive particles of particle size #400, setting a load L to about 100kg, and rotating a sun gear and an internal gear, both surfaces of the glass substrate placed in a carrier were finished to a profile irregularity of 0 to 1μm and a surface roughness Rmax of about 6μm.

(2) Shaping Process

Then, a hole was formed at a center portion of the glass substrate using a cylindrical grindstone and grinding was also applied to an outer peripheral end face to obtain a diameter of 65mmφ, and then, predetermined chamfering was applied to the outer peripheral end face and an inner peripheral end face. In this event, the surface roughness of the end faces (inner peripheral and outer peripheral) of the glass substrate was 4μm in Rmax.

(3) End Face Polishing Process

Then, the end faces (inner peripheral and outer peripheral) of the glass substrate were polished to a surface roughness of 1μm in Rmax and about 0.3μm in Ra by brush polishing while rotating the glass substrate. The surfaces of the glass substrate having been subjected to the above end face polishing process were rinsed with water.

(4) Precision Grinding Process

Then, the particle size of the abrasive particles was changed to #1000 and the surfaces of the glass substrate were ground, thereby obtaining a flatness of 3μm and a surface roughness of about 2μm in Rmax and about 0.2μm in Ra. Rmax and Ra were measured by an atomic force microscope (AFM) (NANOSCOPE manufactured by Digital Instruments Corporation), while, the flatness was measured by a flatness measuring apparatus and represents a distance (difference in elevation) in a vertical direction (direction perpendicular to the surface) between the highest portion and the lowest portion of the substrate surface. The glass substrate having been subjected to the above precision grinding process was immersed in respective cleaning baths of neutral detergent and water in turn, so as to be cleaned.

(5) First Polishing Process

Then, polishing was applied to the glass substrate having been subjected to the foregoing processes. The polishing process is for the purpose

of removing cracks and distortion remaining in the above grinding process and was carried out using a double-side polishing machine. Specifically, using a hard polisher as a polisher, the polishing process was performed under the following polishing conditions:

Polisher : Cerium Oxide (Average Particle Size : 1.5μm) + Water

Load : 80g/cm^2 to 100g/cm^2

Polishing Time : 30min to 50min

Removal Amount : 35μm to 45μm

The glass substrate having been subjected to the above first polishing process was immersed in respective cleaning baths of neutral detergent, pure water, pure water, IPA, and IPA (steam drying) in turn, so as to be cleaned.

(6) Final Polishing Process

Then, a final polishing process was carried out using a double-side polishing machine of the same type as that used in the first polishing process, while the polisher was changed to a soft polisher. The polishing conditions were set as follows:

Polisher : Colloidal Silica (Average Particle Size : 0.03μm, Polishing Particle Concentration : 9wt%, pH 4) containing 1.0wt% of Na_2SO_4 as an additive.

Load : 60g/cm^2 to 120g/cm^2

Polishing Time : 5min to 40min

(7) Cleaning Process after Final Polishing

The glass substrate having been subjected to the above final polishing process was immersed in a KOH aqueous solution with a concentration of 0.1 to 5wt% so as to be subjected to alkali cleaning. The cleaning was carried out while applying an ultrasonic wave. Further, the glass substrate was immersed in respective cleaning baths of neutral detergent, pure water, pure water, IPA, and IPA (steam drying) in turn, so as to be cleaned.

(8) Chemical Strengthening Process

Then, chemical strengthening was applied to the glass substrate having been subjected to the foregoing grinding, polishing, and post-final-polishing cleaning processes. The chemical strengthening was performed by heating a chemical strengthening salt in the form of a mixture of potassium nitrate (60%) and sodium nitrate (40%) to 375°C and immersing therein for about 3 hours the cleaned glass substrate preheated to 300°C. In this manner, by immersing the glass substrate in the chemical strengthening salt, lithium ions and sodium ions in surface layers of the glass substrate are replaced by sodium ions and potassium ions in the chemical strengthening salt, respectively, so that the glass substrate is strengthened. The thickness of each of compressive stress layers formed at the surface layers of the glass substrate was about 100 to 200μm. The glass substrate having been subjected to the chemical strengthening was immersed in a water bath at 20°C so as to be rapidly cooled, and maintained for about 10 minutes.

(9) Cleaning Process after Strengthening

The glass substrate having been subjected to the rapid cooling was immersed in sulfuric acid heated to about 40°C, thereby carrying out cleaning thereof while applying an ultrasonic wave.

With respect to the glass substrate thus obtained, the polishing rate, the surface roughness Ra, and the number of surface defects (cleanness) were examined. The polishing rate was calculated from the weights of the glass substrate measured by a gravimeter before and after the polishing. The surface roughness Ra was examined by an atomic force microscope (AFM) before and after the cleaning after the final polishing. The number of surface defects was examined by an optical defect inspection apparatus (OSA). As to the results thereof, the polishing rate is shown in Fig. 2 and Table 1, the surface roughness Ra before the cleaning is shown in Fig. 3 and Table 1, the surface

roughness Ra after the cleaning is shown in Fig. 4 and Table 1, and the number of surface defects is shown in Fig. 5 and Table 1. With respect to the polishing rate, o is given when it is 0.05μm/min or more and × is given when it is less than 0.05μm/min. With respect to the surface roughness before the cleaning and the surface roughness after the cleaning, o is given when it is 0.12nm or less and × is given when it exceeds 0.12nm. With respect to the number of surface defects, o is given when it is 60 counts or less and × is given when it exceeds 60 counts.

(10) Magnetic Disk Manufacturing Process

On each of both surfaces of the glass substrate obtained through the foregoing processes, an adhesive layer of a Cr alloy, a soft magnetic layer of a CoTaZr-group alloy, an underlayer of Ru, a perpendicular magnetic recording layer of a CoCrPt-group alloy, a protective layer of hydrogenated carbon, and a lubricating layer of perfluoropolyether were formed in this order, thereby manufacturing a perpendicular magnetic recording disk. This structure is one example of the structure of a perpendicular magnetic disk. Magnetic layers and so on may be formed as an in-plane magnetic disk.

With respect to the obtained magnetic disk, it was confirmed that there was no occurrence of defect on the films such as the magnetic layers due to foreign matter. A glide test was performed and there was observed no hit (a head grazes a projection on the magnetic disk surface) or crash (a head collides with a projection on the magnetic disk surface). Further, a reproduction test was performed using a magnetoresistive head and there was observed no malfunction in reproduction due to thermal asperity.

(Example 2)

A glass substrate was manufactured in the same manner as in Example 1 except that, in the final polishing process, final polishing was performed using colloidal silica at pH 6 containing 1.0wt% of Na_2SO_4 as an additive. With

respect to this glass substrate, the polishing rate, the surface roughness Ra, and the number of surface defects were examined in the same manner as in Example 1. The results thereof are also shown in Figs. 2 to 5 and Table 1.

(Comparative Example 1)

A glass substrate was manufactured in the same manner as in Example 1 except that, in the final polishing process, final polishing was performed using colloidal silica at pH 10 containing 1.0wt% of Na_2SO_4 as an additive. With respect to this glass substrate, the polishing rate, the surface roughness Ra, and the number of surface defects were examined in the same manner as in Example 1. The results thereof are also shown in Figs. 2 to 5 and Table 1.

(Comparative Example 2)

A glass substrate was manufactured in the same manner as in Example 1 except that, in the final polishing process, final polishing was performed using colloidal silica at pH 2 containing no additive. With respect to this glass substrate, the polishing rate, the surface roughness Ra, and the number of surface defects were examined in the same manner as in Example 1. The results thereof are also shown in Figs. 2 to 5 and Table 1.

(Comparative Example 3)

A glass substrate was manufactured in the same manner as in Example 1 except that, in the final polishing process, final polishing was performed using colloidal silica at pH 4 containing no additive. With respect to this glass substrate, the polishing rate, the surface roughness Ra, and the number of surface defects were examined in the same manner as in Example 1. The results thereof are also shown in Figs. 2 to 5 and Table 1.

(Comparative Example 4)

A glass substrate was manufactured in the same manner as in Example 1 except that, in the final polishing process, final polishing was performed using colloidal silica at pH 6 containing no additive. With respect to this glass

substrate, the polishing rate, the surface roughness Ra, and the number of surface defects were examined in the same manner as in Example 1. The results thereof are also shown in Figs. 2 to 5 and Table 1.

(Comparative Example 5)

A glass substrate was manufactured in the same manner as in Example 1 except that, in the final polishing process, final polishing was performed using colloidal silica at pH 10 containing no additive. With respect to this glass substrate, the polishing rate, the surface roughness Ra, and the number of surface defects were examined in the same manner as in Example 1. The results thereof are also shown in Figs. 2 to 5 and Table 1.

Table 1

	Polishing Rate	Surface Roughness Before Cleaning	Surface Roughness After Cleaning	Cleanness
Example 1	o	o	o	o
Example 2	o	o	o	o
Comparative Example 1	×	o	o	o
Comparative Example 2	o	o	×	o
Comparative Example 3	o	o	o	×
Comparative Example 4	×	o	o	×
Comparative Example 5	×	o	o	×

As shown in Fig. 2, the polishing rate was faster as the pH was smaller, i.e. as the solution property of the polisher was more into the acidic region. At the same pH, the polishing rate was faster in the case where the additive was added (Example 1, 2). For example, by adding the additive at pH 4, the polishing rate equivalent to that at pH 2 was obtained. This is considered to be

caused by the fact that the isoelectric point approached zero at that pH so that aggregation of the polishing particles proceeded to increase the secondary particle size thereof. On the other hand, when the solution property of the polisher was in the alkaline region (Comparative Example 1, 5) or when the solution property of the polisher was in the weak acidic region with no additive (Comparative Example 4), the polishing rate was not fast. This is considered to be caused by the fact that the isoelectric point did not approach zero at that pH so that aggregation of the polishing particles did not proceed and thus the secondary particle size thereof did not increase.

As shown in Fig. 3, with respect to the surface roughness before the cleaning, the values were approximately the same for all the glass substrates, while, as shown in Fig. 4, with respect to the surface roughness after the cleaning, the value became very high when the solution property of the polisher was in the acidic region with no additive (Comparative Example 2). This is considered to be caused by the fact that a leaching layer was formed deep by the polishing in the acidic region.

With respect to the number of surface defects (cleanness), it was small when the zeta potential of the colloidal silica was zero (Comparative Example 2) or when the zeta potential was caused to approach zero by the use of the additive (Example 1, 2, Comparative Example 1). This is considered to be caused by the fact that the zeta potential of the glass substrate surface approached the isoelectric point so that foreign substances having plus potentials were reluctant to adhere to the glass substrate surface. On the other hand, when the zeta potential of the colloidal silica was zero or did not approach zero (Comparative Example 3, 4, 5), the number of surface defects was large. This is considered to be caused by the fact that the zeta potential of the glass substrate surface did not approach the isoelectric point so that foreign substances having plus potentials were liable to adhere to the glass

substrate surface.

As described above, it has been understood that since, in the method according to this invention, the polisher containing the additive serving to increase the electrolyte concentration in the polisher without changing the pH of the polisher is used in the final polishing, it is possible to simultaneously realize a low-level surface roughness, a low-level surface defect, and a fast polishing rate.

This invention is not limited to the foregoing embodiment and can be carried out with appropriate changes thereto. The materials, the sizes, the process sequence, and so on in the foregoing embodiment are only one example and thus it can be carried out with various changes within a range where the effect of this invention is achieved. In addition, it can be carried out with appropriate changes as long as not departing from the scope of the object of this invention.

CLAIMS

1. A method of manufacturing a magnetic-disk glass substrate, the method including a polishing step of polishing a main surface of a glass substrate using a polisher and a cleaning step of cleaning said glass substrate after the polishing step, characterized in that:

said polisher has a pH of 4 to 6 and contains polishing particles, a dispersion medium serving to disperse said polishing particles, and an additive serving to increase an electrolyte concentration in said polisher without changing the pH of said polisher, said polishing step being performed using said polisher;

wherein said cleaning step includes cleaning using an alkaline chemical solution.

2. A method of manufacturing a magnetic-disk glass substrate, the method including a polishing step of polishing a main surface of a glass substrate using a polisher and a cleaning step of cleaning said glass substrate after said polishing step, characterized in that:

said polisher has a pH of 4 to 6 and contains polishing particles having a predetermined zeta potential, a dispersion medium serving to disperse said polishing particles, and an additive serving to cause said zeta potential to approach zero at said pH, said polishing step being performed using said polisher;

wherein said cleaning step includes cleaning using an alkaline chemical solution.

3. A method of manufacturing a magnetic-disk glass substrate according to claim 1 or 2, characterized in that said polisher is colloidal silica and said additive is at least one selected from the group consisting of a sulfuric acid compound, a phosphoric acid compound, and a nitric acid compound.

4. A method of manufacturing a magnetic-disk glass substrate according to any one of claims 1 to 3, characterized in that an addition amount of said additive is 0.1wt% to 5.0wt% relative to the total weight of said polisher.

5. A method of manufacturing a magnetic-disk glass substrate according to any one of claims 1 to 4, characterized in that the main surface of the glass substrate after said cleaning step has a surface roughness (Ra) of 0.12 nm or less.

6. A method of manufacturing a magnetic-disk glass substrate according to any one of claims 1 to 5, characterized in that a polishing rate in said polishing step is not less than 0.05 μm/min.

7. A method of manufacturing a magnetic disk, characterized in that, on a magnetic-disk glass substrate obtained by the method according to any one of claims 1 to 6, a magnetic layer is formed directly or through another layer.