

GLASS SUBSTRATE FOR MAGNETIC DISC

The present disclosure relates to subject matters contained in Japanese Patent Application No. filed on , which are expressly incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a glass substrate for a magnetic disc used for a magnetic disc.

Description of the Related Art

[0002] Along with advancement of information technology, information recording technology, especially magnetic recording technology has been significantly improving. As a magnetic recording medium mounted on a hard disc drive (HDD), which is one of the magnetic recording media, or the like, a magnetic disc has been known. The magnetic disc is configured by including a film of nickel phosphate (NiP) or the like which is deposited on a metal substrate of aluminum-magnesium alloy or by sequentially laminating a foundation layer, a magnetic layer, a protection layer, and a lubrication layer on a glass substrate or a ceramics substrate. An aluminum has been widely used as a substrate for a magnetic disc conventionally. However, along with space saving, flattening, and high density recording of the magnetic disc, the aluminum substrate is replaced by a

glass substrate having superior flatness and substrate strength of the substrate surface to an aluminum substrate.

[0003] Moreover, a glass substrate having high rigidity has an advantage because improvement of anti-shock property is required if a large-volume substrate is to be mounted on a mobile phone or an automobile. Size of a substrate has been miniaturized to be mounted in a mobile phone. Therefore, a 1.8-inch substrate, a 1-inch substrate or a smaller substrate has been requested instead of a conventional 3.5-inch or 2.5-inch substrate. As the substrate becomes smaller, dimension error becomes smaller and more precise shaping is demanded.

[0004] Further, as density growth of magnetic recording technology is progressed, a magnetic head has changed from a thin film head to a magnetoresistance head (MR head) to a giant magnetic resistance head (GMR head) and floating amount of a magnetic head from a substrate has been narrowed to 10nm or less. Because higher recording density is demanded in the future, along with such a demand, a magnetic head is also demanded to float lower.

[0005] As a technique to stabilize control of the above-mentioned floating amount of a magnetic head to realize lower floating amount, a technique called dynamic flying height (DFH) has been recently developed. A heater element is embedded in a magnetic head. The heater element generates heat when the magnetic head is operated and the magnetic head is thermally expanded by the heat and is slightly projected to a magnetic

disc. Thus, it is possible to set a magnetic spacing which is magnetic space between the magnetic head and the magnetic disc to be small only at that time. In other words, DFH is a technique which enables to lower floating amount of the magnetic head from the magnetic disc.

[0006] Lower floating amount is realized by the DFH head. However, an MR element is mounted in a magnetic head and as unique troubles thereof, head crash or thermal asperity may occur. Because they are caused by fine convex or concave irregularity on the magnetic disc surface, the magnetic disc surface is required to have high smoothness and flatness.

[0007] Above-mentioned glass substrate can be manufactured by cutting a plate glass in an annular shape. The plate glass can be manufactured by a heretofore known method such as a down-draw method, a press method, a float method, a redraw method, and a fusion method shown in the Patent Document 1 (Japanese Published Unexamined Patent Application No. H09-124345) using, for example, molten glass as a material. [Patent Document 1] Japanese Published Unexamined Patent Application No. H09-124345

[0008] Meanwhile, there is a case where a foreign matter (impurity) inevitably contaminates a glass substrate in a manufacturing process. There are two types of the foreign matter: one is that contaminates from the manufacturing equipment, the other is material of blank (plate glass) which did not melt and remained to be a crystal. An example of the former includes platinum (Pt) and boron (B) which are materials

of a melting furnace. The latter includes zirconium (Z), lithium (Li) and the like.

[0009] Then, the foreign matter exists as a crystal in the glass. Although main surface or edge surface is ground and polished many times in the process of manufacturing a glass substrate, part of a foreign matter is exposed from a surface layer of the glass substrate while the rest is included in the glass substrate.

[0010] In a case where the foreign matter is exposed on the surface layer of the glass substrate, because hardness thereof is different from that of the glass surrounding the foreign matter, the surface layer does not come to have enough smoothness by mirror polishing and there is a possibility that low floating amount of a magnetic head is prevented. Moreover, since the foreign matter is crystallized, amorphous soft magnetic layer is slightly crystallized and domain wall noise (magnetic wall noise) is increased. Further, an adherent layer for closely adhering the foundation layer to the substrate is also slightly crystallized and therefore there occurs variation in adherence in the adherent layer, causing lowered adherence. Further, crystal orientation of the recording layer may be disarranged and there is a possibility that improvement of S/N ratio is prevented.

[0011] Conventionally, the above-mentioned problems did not occur because floating amount of the magnetic head was large. However, due to demand for high recording density in recent years, that is, demand for lower floating amount, they became

problems.

[0012] In other words, unlike a foreign matter attached on the surface of the substrate, it is difficult to remove foreign matter with a part thereof exposed from the surface layer of the substrate by cleansing. Moreover, since greater part of the foreign matter exists in the substrate, if it is removed in the polishing process, there occurs a concave defect on the glass substrate. Therefore, such a cause which increases roughness becomes an important problem when a substrate with a surface roughness (arithmetic mean roughness) R_a of 0.3 nm is manufactured along with a demand for the above-mentioned low floating amount.

[0013] Moreover, in a case where a foreign matter is included in the glass substrate, difference in thermal expansion coefficient between the glass substrate and the foreign matter becomes a problem. Each of the layers such as the foundation layer, soft magnetic layer, and recording layer is formed by sputtering and this processing includes sudden heating processing. Then, because the amount of expansion of the foreign matter and the glass substrate differ due to the difference in thermal expansion coefficient, there is a case where the glass substrate is broken. If the glass substrate is broken during the sputtering processing, not only is the glass substrate lost, but it becomes impossible to carry out the processing for other glass substrates without removing debris that flew. Therefore, manufacturing process is heavily influenced.

SUMMARY OF THE INVENTION

[0014] Therefore, the present invention aims at providing a glass substrate for a magnetic disc which significantly lowers influence by a foreign matter in the manufactured magnetic disc and in the manufacturing process thereof, on an assumption that it is impossible to prevent contamination.

[0015] To solve the above-mentioned problems, a typical configuration of a glass substrate for a magnetic disc according to the present invention is a glass substrate for a magnetic disc for manufacturing a magnetic disc by forming a magnetic layer wherein a foreign matter, which is included in the glass substrate, exists in a surface layer of the glass substrate for a magnetic disc, the glass substrate being amorphous glass, and the size of the foreign matter is within a size that does not prevent float of a magnetic head when a magnetic disc is manufactured by forming a magnetic layer and incorporated into a magnetic recording medium.

[0016] A specific configuration wherein the size of the foreign matter does not prevent float of the magnetic disc includes a glass substrate for a magnetic disc for manufacturing a magnetic disc by forming a magnetic layer wherein a foreign matter exists in a surface layer of the glass substrate while part thereof being embedded in the glass substrate and the other part being exposed from the glass substrate and the size of the foreign matter existing in the surface layer is limited to a predetermined size or smaller for floating amount of a magnetic

head.

[0017] Here, the size of a foreign matter can be understood as diameter of a circumscribing circle of the foreign matter. However, because the foreign matter is partially embedded, protruding height from the main surface of the glass substrate, dimension of the bottom part of the protrusion, or a combination thereof can be a standard. That is, although the size of the foreign matter basically must be equal to or smaller than floating amount of a head, even if height of the protrusion is higher than the floating amount of the magnetic head, if the protrusion is extremely thin and tapered, crash does not occur even when the magnetic head hits the protrusion. Therefore, it is possible to regulate the size of the foreign matter by use of a combination of the height of protruding portion of the foreign matter and dimension of the bottom part thereof.

[0018] According to the above configuration, it is possible to significantly lower influence of the foreign matter existing in the surface layer of the glass substrate, to enhance lower floating amount of the magnetic head, and to improve high recording density of the magnetic disc.

[0019] Moreover, material of the foreign matter may be platinum. Many types are included in the foreign matter which inevitably contaminates the glass substrate. Especially, if platinum (Pt) which is material of a melting furnace contaminates, because Pt is crystallized foreign matter, a soft magnetic layer may be crystallized and domain wall noise (magnetic wall noise) may be easily formed. However, according

to the present invention, even if the foreign matter is Pt, it is possible to prevent forming of domain wall noise.

[0020] It is preferable that the size of the foreign matter existing in the surface layer is 2 μm or less. Then, it is possible to more surely eliminate influence by the foreign matter.

[0021] The foreign matter existing in the surface layer may have a crystal structure. Even in case of a crystallized foreign matter, it is possible to eliminate the influence thereof according to the present invention and therefore it is possible to prevent formation of domain wall noise (magnetic wall noise) by crystallization of the soft magnetic layer.

[0022] It is preferable that dimension of an aperture of a portion on the surface layer where the foreign matter is embedded is 3.14 μm^2 or less. Thus, it is possible to surely prevent decrease in surface roughness.

[0023] It is preferable that the size of the foreign matter existing in the surface layer is 10 times or less than the lead track width. Thus, it is possible to efficiently prevent decrease in surface roughness.

[0024] Moreover, a typical configuration of a glass substrate for a magnetic disc according to the present invention includes a processing step which includes heating and a processing step for forming a magnetic layer to manufacture a glass substrate for a magnetic disc wherein it is preferable that the size of a foreign matter included in the glass substrate

is 5 μm or less.

[0025] According to the above configuration, it is possible to significantly lower influence of the foreign matter existing in the surface layer of the glass substrate, to enhance lower floating amount of the magnetic head, and to improve high recording density of the magnetic disc.

[0026] A glass substrate for manufacturing a magnetic disc through a processing step including heating and a step of forming a magnetic layer wherein the size of a foreign matter included in the glass substrate is preferably 5 μm or less.

[0027] The glass substrate for a magnetic disc may be used to manufacture a magnetic disc which uses a DFH head for recording. The glass substrate for a magnetic disc manufactured by a manufacturing method according to the present invention enhances lower floating amount of a magnetic disc than a glass substrate for a magnetic disc manufactured by a conventional method. Therefore, it is appropriate that the glass substrate for a magnetic disc according to the present invention is used for a magnetic disc which employs magnetic recording method using a DFH head having low floating amount of a magnetic head.

[0028] The above-mentioned magnetic layer may be a perpendicular magnetic recording layer. As mentioned above, a magnetic disc manufactured by the manufacturing method according to the present invention hardly forms domain wall noise and therefore is suitable for a perpendicular magnetic recording medium which requires high recording density. That

is, a perpendicular magnetic recording medium including the glass substrate for a magnetic disc including an adherent layer, a soft magnetic layer, a foundation layer, and a perpendicular magnetic recording layer can achieve high recording density.

[0029] According to the present invention, it is possible to provide a glass substrate for a magnetic disc wherein influence by a foreign matter existing in the glass substrate is significantly reduced in the manufactured magnetic disc and in the manufacturing process thereof.

The Best Mode for Carrying Out the Claimed Invention

[0030] An embodiment of a glass substrate for a magnetic disc according to the present invention will be explained. Here, dimension, material, and other specific numerical numbers shown in the following embodiments are just examples for easy of understanding and except for a case where there is a notice, the present invention is not limited thereto.

[0031] As a result of keen discussion to achieve lower floating amount of a magnetic head to achieve high recording density, the inventors found out that there are cases where a foreign matter contaminates in a glass substrate and this is one of causes that prevents low floating amount. Moreover, it was found out that if the foreign matter is a crystallized foreign matter, it also gives various influence. Further, it was found out that the foreign matter inevitably contaminates in the manufacturing process of a glass and it is quite difficult to completely prevent contamination. Then, the inventors

found out that influence by a foreign matter in a manufactured magnetic disc and in the manufacturing process thereof can be significantly reduced by regulating a permissible range for a foreign matter inevitably existing in a glass substrate. Thus, the present invention has been made.

[0032] A glass substrate for a magnetic disc according to the present embodiment will be explained. In the present embodiment, a glass substrate is manufactured through the process of: forming molten glass into a plate glass by a down-draw method; first wrapping step (grinding); cutting step; second wrapping step; main surface polishing step (first polishing step and second polishing step); and chemical strengthening step, as described later.

[0033] In the step of forming a plate glass, a plate glass including amorphous glass was formed by use of a furnace including platinum. Among various types of amorphous glass, aluminosilicate glass was used.

[0034] On the glass substrate, a magnetic disc is manufactured by forming an adherent layer, a soft magnetic layer, a foundation layer, a first magnetic recording layer, a second magnetic recording layer, a coupling controlling layer, an exchange coupling layer, a medium protection layer, and a lubrication layer. From the adherent layer to the exchange coupling layer, films are formed sequentially by DC magnetron sputtering method in an atmosphere of Ar using a deposition system after vacuuming. The medium protection layer is deposited by CVD method and the lubrication layer is deposited

by dip coat method.

[0035] Inspecting an obtained glass substrate, a foreign matter contaminated in the glass substrate. The foreign matter was a crystal matter including crystal of a metal. There are two types of the foreign matter: one is that contaminates from the manufacturing equipment, the other is material of blank (plate glass) which did not melt and remained to be a crystal. An example of the former includes platinum (Pt) and boron (B) which are materials of a melting furnace. The latter includes zirconium (Zr), lithium (Li) and the like. In the present invention, the metal was Pt and because Pt was not included in the material of the glass, it is assumed that it is from the furnace and contaminated when the glass substrate was molten.

[0036] Some foreign matters exist in the surface layer of the glass substrate in a condition where a part thereof is embedded in the glass substrate while the other part is exposed from the glass substrate. Some foreign matters are included in the glass substrate. The foreign matter existing in the surface layer was one that was exposed from the surface payer of the glass substrate by the wrapping step or polishing step.

[0037] Here, in a case where the foreign matter is exposed on the surface layer of the glass substrate, because hardness thereof is different from that of the glass surrounding the foreign matter, the surface layer does not have enough smoothness by mirror polishing and there is a possibility that low floating amount of a magnetic head is prevented. Moreover, since the foreign matter is crystallized, amorphous soft

magnetic layer is slightly crystallized. Further, the adherent layer for closely adhering the foundation layer to the substrate is also slightly crystallized and therefore there is a possibility that adherence in the adherent layer varies and adherence is lowered. Further, crystal orientation of the recording layer may be disarranged and there is a possibility that improvement of S/N ratio is prevented.

[0038] Further, in a case where a foreign matter is included in the glass substrate, due to the difference in thermal expansion coefficient between the glass substrate and the foreign matter, there is a possibility that the glass is broken. As mentioned above, each of the layers such as the foundation layer, soft magnetic layer, and recording layer is formed by sputtering and this processing includes sudden heating processing. Then, because the amount of expansion of the foreign matter and the glass substrate differ due to the difference in thermal expansion coefficient, if the glass substrate is broken during the sputtering processing, not only is the glass substrate lost, but it becomes impossible to carry out the processing for other glass substrates without removing debris that flew. Therefore, manufacturing process is heavily influenced.

[0039] Therefore, it was determined that in the present embodiment, contamination of a foreign matter in the manufacturing process of the glass substrate will be inspected and a foreign matter judgment step for judging whether the existence of a foreign matter is permissible or not will be

carried out. It is preferable that the foreign matter judgment step will be carried out after permissibility of the glass substrate is obtained and can be carried out at any step after the first polishing step of the main surface polishing.

[0040] It was regulated that the foreign matter existing in the surface layer of the glass substrate should not have a size large enough to prevent float of the magnetic head when a magnetic disc is manufactured to manufacture a magnetic recording medium. This means that the size of a foreign matter existing in the surface layer has a diameter of 2 μm or less. Moreover, dimension of an aperture of a portion on the surface layer where the foreign matter is embedded is 3.14 μm^2 or less. Further, it is preferable that the size of the foreign matter existing in the surface layer is 10 times or less than the lead track width.

[0041] The magnetic layer is for magnetically recording information and the recording layer for recording information and the soft magnetic layer for controlling direction of magnetization correspond thereto (depending on the configuration of the magnetic disc, there may be a case where the soft magnetic layer does not exist). If a crystal foreign matter is exposed on the surface layer and therefore the size of the foreign matter should be the size that does not crystallize the amorphous soft magnetic layer and also the size that does not crystallize the amorphous adherent layer.

[0042] Size of the foreign matter is measured by an optical microscope and diameter of a circumscribing circle of the

(crystal) foreign matter when the (crystal) foreign matter is observed from a direction orthogonal to the substrate surface can be understood as the size. Specifically, the diameter can be 2 μm or less. Thus, the above-mentioned conditions can be fulfilled without fail. At this time, the substrate surface roughness Ra was 0.3 nm or less. Here, Ra was calculated on the basis of data obtained by dividing a measurement area of 100 μm x 100 μm by a mesh of 256 x 256 using, for example, an AFM.

[0043] In a case that the foreign matter is included inside of the glass substrate, there is a possibility that crack occurs due to difference in thermal expansion coefficient of the glass and the foreign matter in the sputtering process which includes heating. When the thermal expansion coefficient differs, size of the foreign matter must be the one that does not damage the glass substrate by change of temperature in the heating process. Therefore, the size of the foreign matter is set to be the one that does not cause crack even when sudden heating is carried out. Moreover, standard for a foreign matter included in the glass substrate was determined on the basis of understanding of relation between the foreign matter included in the glass substrate and breakage ratio of glass substrates when the glass substrates are heat processed so that breakage ratio of the glass substrates is set within a permissible range.

[0044] Specifically, size of a foreign matter included in the glass substrate was set to be 5 μm or less. Thus, even when thermal gradient was 25°C/sec, crack did not occur.

[0045] According to the above configuration, it is possible to significantly lower influence of the foreign matter existing in the surface layer of the glass substrate and a foreign matter included in the glass substrate, to enhance lower floating amount of the magnetic head, and to improve high recording density of the magnetic disc.

[0046] Therefore, the present invention can be used for a magnetic disc which records information by a low floating amount magnetic head, that is, a recording medium having a magnetic head with 10nm or less of floating amount, and requires high smoothness and flatness. Moreover, from the same viewpoint, the glass substrate can be suitably used for a magnetic disc which records information by magnetic recording method using a DFH head having low floating amount of a magnetic head.

[0047] It is preferable that the glass substrate for a magnetic disc is used for a magnetic disc having a touch down height (TDH) of 3 to 4 nm or less. If the touch down height is too low, crash may be occurred often in a case where the fluctuation of deviation formed on the glass substrate is large. However, using the glass substrate for a magnetic disc of the present embodiment enables to reduce fluctuation of deviation portion than a conventional one. Therefore, if floating amount of the magnetic head (recording head) is small, the magnetic head can be prevented from crash.

[0048] Moreover, it is preferable that the glass substrate for a magnetic disc according to the present embodiment is used

for a magnetic disc having high recording density of 200 Gbit/inch², or more preferably, 250 Gbit/inch². In the case of such a high recording density, it is required to set floating amount of the recording head smaller. By use of the glass substrate for a magnetic disc of the present embodiment enables to lower floating amount of the recording head and therefore crash can be prevented. Here, it is needless to say that the glass substrate for a magnetic disc according to the present invention can be preferably used for a glass substrate used for a magnetic disc having smaller recording density than the above or for a glass substrate for a magnetic disc for manufacturing a magnetic disc having larger touch down height than the above.

[Embodiments]

[0049] Hereinafter, embodiments of a manufacturing method of a glass substrate for a magnetic disc and a magnetic disc to which the present invention is applied will be explained. The glass substrate for a magnetic disc and the magnetic disc are manufactured as a magnetic disc having a predetermined shape such as a 3.5-inch disc (ϕ 89 mm), a 2.5-inch disc (ϕ 65 mm), a 0.8-inch disc (ϕ 21.6 mm), a 1.0-inch disc (ϕ 27.4 mm) or a 1.8-inch disc (ϕ 48 mm).

[0050]

(1) Shaping step and first wrapping step

In the manufacturing method of a glass substrate for a magnetic disc according to the present embodiment, surface of a plate glass is wrapping processed (ground) to produce a glass base material. Then the glass base material is cut to produce

a glass disc. Various types of plate glass can be used as the plate glass. The plate glass can be manufactured by a heretofore known method such as a down-draw method, a press method, a float method, a redraw method, and a fusion method with, for example, molten glass as a material. Among these methods, if press method is used, the plate glass can be manufactured at a low cost. Amorphous glass, glass ceramics (crystallized glass), aluminosilicate glass, soda line glass, boronsilicate glass, or the like can be used as material of the plate glass. Especially, the amorphous glass can be preferably used because it can be chemically strengthened and can provide a glass substrate for a magnetic disc having superior main surface flatness and substrate strength.

[0051] In the present embodiment, molten aluminosilicate glass is cast into disc-shape by direct press using upper, lower, and body molds to obtain a plate-shaped amorphous glass. Here, as the aluminosilicate glass, chemical strengthening glass including; 58 to 75 percent by weight of SiO_2 ; 5 to 23 percent by weight of Al_2O_3 ; 3 to 10 percent by weight of Li_2O , and 4 to 13 percent by weight of Na_2O , is used.

[0052] Next, both main surfaces of the plate glass is wrapping processed to make a disc-shaped base glass material. The wrapping process is carried out by an apparatus for both surfaces wrapping using planetary gear mechanism and alumina system loose grain is used. Specifically, wrapping platen is pressed both from top and bottom of the plate glass, grinding fluid containing loose grain is supplied on the main surface

of the plate glass, and they are relatively moved to carry out the wrapping process. By this wrapping process, a glass base material having smooth main surface is obtained.

[0053]

(2) Cutting step (coring, forming, chamfering)

Next, using a diamond cutter, the glass base material is cut and a disc-shaped glass substrate is cut out from the glass base material. Next, using a diamond drill, an inner hole is formed in the center of the glass substrate to form a toric glass substrate (coring). Then, inner circumference edge surface and outer circumference edge surface are ground by a diamond grinder to carry out predetermined chamfering process (forming, chamfering).

[0054]

(3) Second wrapping step

Next, on both surfaces of the glass substrate thus obtained, second wrapping process is carried out in a similar manner as the first wrapping process. By carrying out the second wrapping process, it is possible to remove minute convex or concave shape formed on the main surface in the cutting step or edge surface polishing step, which are precedent steps, in advance and it becomes possible to finish following polishing step of the main surface in a short period of time.

[0055]

(4) Edge polishing step

Next, by brush polishing method, outer and inner circumference edge surfaces of the glass substrate are mirror

polished. At this time, slurry including cerium oxide abrasive grain (loose grain) is used as polishing grain.

[0056] Then, the glass substrate after edge surface step is cleansed with water. By this edge surface polishing step, the edge surface of the glass substrate is processed to have a mirror surface condition which can prevent separation of sodium or potassium.

[0057]

(5) Main surface polishing step

As a main surface polishing step, the first polishing step was performed. The first polishing step is mainly aimed at removing crack or distortion remaining on the main surface after the wrapping step. In the first polishing step, main surface was polished by an apparatus for both surfaces wrapping using planetary gear mechanism, using hard resin polisher. As polishing liquid, cerium oxide abrasive grain used in the first polishing step was used.

[0058] The glass substrate after the first polishing step was sequentially dipped in cleansing tanks of neutral detergent, pure water, and isopropyl alcohol (IPA) to be cleansed.

[0059] Completing the first polishing step, a foreign matter judgment step was carried out. In an inspection step, size of a foreign matter was measured by use of an optical microscope and diameter of a circumscribing circle of the (crystal) foreign matter when the (crystal) foreign matter was observed from a direction orthogonal to the substrate surface was measured as the size of the foreign matter. When the size

was larger than 2 μm , it was rejected while one having the size of 2 μm or less passed.

[0060] Next, second polishing step was performed as the main surface polishing step. The second polishing step is aimed at finishing the main surface to have a mirror surface. In the second polishing step, main surface was polished by an apparatus for both surfaces wrapping using planetary gear mechanism, using flexible resin foam polisher. As polishing liquid, cerium oxide abrasive grain having finer grain than the cerium oxide abrasive grain used in the first polishing step was used.

[0061] The glass substrate after the second polishing step was sequentially dipped in cleansing tanks of neutral detergent, pure water, and isopropyl alcohol (IPA) to be cleansed. Here, ultrasonic wave was applied to the tanks.

[0062]

(6) Chemical strengthening step

Next, chemical strengthening was conducted to the glass substrate after the above-mentioned wrapping and polishing steps. The chemical strengthening was conducted by preparing chemical strengthening solution in which 60% of potassium nitrate and 40% of sodium nitrate are mixed. The chemical solution was heated to 400°C and the cleansed glass substrate was heated to 300°C. Then, the glass substrate was dipped into the chemical strengthening solution for about 3 hours. To chemically strengthen the whole surfaces of the glass substrate, the dipping was conducted while the glass substrate was placed in a holder so that a plurality of glass substrates are retained

by their edge surface.

[0063] By dipping the glass substrate into the chemical strengthening solution, lithium ion and sodium ion on the surface layer of the glass substrate are replaced by sodium ion and potassium ion in the chemical strengthening solution and the glass substrate is strengthened. Thickness of compression stress layer formed on the surface layer of the glass substrate was between about 100 μm and 200 μm .

[0064] The glass substrate after the chemical strengthening step is dipped into a water tank of 20°C to be rapidly cooled down and was kept in the tank for about 10 minutes. Then, the glass substrate after the rapid cool down is dipped in concentrated sulfuric acid heated to about 40°C to be cleansed. Moreover, the glass substrate after cleansing by the concentrated sulfuric acid is sequentially dipped into tanks of pure water and IPA to be cleansed.

[0065] As mentioned above, by carrying out the first wrapping step, the cutting step, the second wrapping step, the edge surface polishing step, the first and second polishing steps, and the chemical strengthening step, a flat and smooth glass substrate for a magnetic disc having high rigidity is obtained.

[0066]

(7) Magnetic disc manufacturing step

As mentioned above, an inspection is carried out after the first polishing step. An adherent layer including Cr, a soft magnetic layer including CoTaZr base alloy, a foundation layer

including Ru, a perpendicular magnetic recording layer including CoCrPt, an exchange coupling layer, a protection layer including carbon hydroxide, and a lubrication layer including perfluoropolyether (PFPE) are sequentially deposited on both surfaces of a glass substrate manufactured through the above procedures to manufacture a perpendicular magnetic disc. Here, the present configuration is an example of a perpendicular magnetic disc (PMR). However, the above example may include a magnetic layer or the like as a longitudinal magnetic disc. Thus, a magnetic disc including high flatness on the outer periphery portion of the main surface can be manufactured.

[0067]

(8) Comparison between embodiments and comparison examples

Foreign matters existing in the surface layer of the glass substrate of embodiments 1 to 3 and comparison examples 1 and 2 shown in Table 1 were compared. Diameters of foreign matters of embodiments 1 to 3 are 0.7 μ m, 1.0 μ m, and 2.0 μ m, respectively, while that of the comparison examples 1 and 2 were 5.0 μ m and 7.0 μ m.

[Table 1]

	Diameter of foreign matter (μm)	Glide hit number (Glide height; 5 nm)	Glide hit number (Glide height; 7 nm)
Embodiment 1	0.7	0	0
Embodiment 2	1.0	0	0
Embodiment 3	2.0	0	0
Comparison example 1	5.0	8	5
Comparison example 2	7.0	10	7

[0068] As shown in Table 1, crash did not occur in the configuration of the embodiment when the glide height was set to 5 nm and 7 nm. In the configuration of the comparison examples, crash occurred in both of the cases and the number of crash increased as the glide height was set lower. Moreover, in the comparison examples, S/N ratio is worse than the embodiment and spike noise from the soft magnetic layer was also observed.

[0069] It is understood from the above result that regulating the diameter of the foreign matter enables to significantly reduce influence by the foreign matter existing in the surface layer of the glass substrate, to enhance low floating amount of the magnetic head, and as a result, to achieve high recording density of the magnetic disc. Especially, by

regulating the size of a foreign matter existing in the surface layer to 2 μ m or less, influence by the foreign matter could be prevented without fail. This is assumed to be because formation of domain wall noise as a result of crystallization of the soft magnetic layer is prevented.

[0070] Embodiments 4 to 6 and comparison examples 3 to 5 were compared for a case where a foreign matter is included inside of the glass substrate, as shown in Table 2. Diameter of the foreign matters in embodiments 4 to 6 were 2 to 5 μ m and tensile strength of each of them was 4.0, 3.0, and 5.0 kg/cm², respectively. Diameter of the foreign matters in comparison examples were larger, 7 to 10 μ m. Tensile strength of each of them was 3.0, 4.0, and 3.0 kg/cm², respectively.

[Table 2]

	Diameter of foreign matter (μ m)	Tensile strength (kg/cm ²)	Breakage rate (%) N=10,000
Embodiment 4	2.0	4.0	0.00
Embodiment 5	3.0	3.0	0.00
Embodiment 6	5.0	5.0	0.00
Comparison example 3	7.0	3.0	0.03
Comparison example 4	9.0	4.0	0.05
Comparison	10.0	3.0	0.05

example 5			
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[0071] Here, breakage rate means number of broken glass substrates when the temperature of the glass substrates were suddenly raised from room temperature (25°C) to 300°C within a predetermined period of time (e.g., 10 seconds). Here, thermal gradient may be 25°C/sec, as mentioned above. Moreover, tensile stress inside of the glass substrate is 4kg/cm² and thickness of the glass was 0.635 mm or less.

[0072] Then, as shown in Table 2, although their tensile stress are similar, breakage rate in the configuration of the present embodiment is close to 0 while some glass substrates were broken by the configuration of the comparison examples. It is understood from the Table that even in a case where a foreign matter is included inside of the glass substrate, regulating the diameter of the foreign matter small enables to prevent breakage of the glass substrate and significantly reduce influence to the manufacturing process.

[0073] A preferred embodiment of the present invention was explained with reference to attached figures. However, it is needless to say that the present invention is not limited to this example. As will be understood by the skilled persons, various modifications and variations of the present invention are possible in the light of the scope of the subjoined claims and therefore all the modifications and variations fall within the technical scope of the present invention.

[0074] For example, in the glass substrate for a magnetic

disc according to the present invention, a foreign matter is included inside of the glass substrate and exists on the substrate surface of a glass substrate, the glass substrate being amorphous glass, and the foreign matter may have any size unless the foreign matter prevents float of a magnetic head when a magnetic disc is manufactured by forming a magnetic layer for magnetic recording on the glass substrate to manufacture a magnetic recording medium.

[0075] Moreover, a crystallized foreign matter may exist on the surface of the glass substrate, the glass substrate being amorphous glass and the amount of the crystallized foreign matter may be any amount unless the foreign matter prevents formation of a magnetic layer when the magnetic layer for magnetic recording is formed on the substrate.

[0076] Further, the glass substrate according to the present invention is a glass substrate for a magnetic disc corresponding to a manufacturing method of a magnetic disc including temperature processing and processing to deposit a recording layer on the surface of the glass substrate and size of a foreign matter included inside the glass substrate may be 2 μm or less.

[0077] Further, the glass substrate according to the present invention is a glass substrate for a magnetic disc corresponding to a manufacturing method of a magnetic disc including temperature processing and processing to deposit a recording layer on the surface of the glass substrate and the foreign matter having difference thermal expansion coefficient

from that of the glass substrate included inside of the glass substrate may have any size unless the foreign matter causes breakage in the temperature processing of the glass substrate (due to change of temperature).

[0078] Further, the glass substrate according to the present invention is a glass substrate for a magnetic disc corresponding to a manufacturing method of a magnetic disc including temperature processing and processing to deposit a recording layer on the surface of the glass substrate wherein relation between a foreign matter included inside the glass substrate and breakage rate of glass substrate when the glass substrate is heat processed is understood and a standard for the size of the foreign matter included inside the glass substrate may be determined so that breakage rate of the glass substrate is set within permissible range.

[0079] The present invention can be used as a glass substrate for a magnetic disc used for a magnetic disc.

What is claimed is:

1. A glass substrate for a magnetic disc for manufacturing a magnetic disc by forming a magnetic layer,

wherein a foreign matter exists in a surface layer of the glass substrate for a magnetic disc while part thereof being embedded in the glass substrate and the other part being exposed from the glass substrate, the glass substrate being amorphous glass; and

the size of the foreign matter is within a size that does not prevent float of a magnetic head when a magnetic disc is manufactured by forming a magnetic layer and incorporated into a magnetic recording medium.

2. The glass substrate for a magnetic disc according to claim 1, wherein the foreign matter is Pt.

3. The glass substrate for a magnetic disc according to claim 1, wherein size of the foreign matter existing in the surface layer is $2\mu\text{m}$ or less.

4. The glass substrate for a magnetic disc according to claim 1, wherein the foreign matter existing in the surface layer has a crystal structure.

5. The glass substrate for a magnetic disc according to claim 1, wherein dimension of an aperture of a portion on the surface layer where the foreign matter is embedded is $3.14\mu\text{m}^2$ or less.

6. The glass substrate for a magnetic disc according to claim 1, wherein the size of the foreign matter existing in the surface layer is 10 times or less than the lead track width.
7. A glass substrate for manufacturing a magnetic disc through a processing step including heating and a step of forming a magnetic layer,
wherein the size of a foreign matter included inside the glass substrate is preferably 5 μm or less.
8. The glass substrate for a magnetic disc according to either claim 1 or 7,
wherein the glass substrate for a magnetic disc is used to manufacture a magnetic disc which uses a DFH head for recording.
9. The glass substrate for a magnetic disc according to either claim 1 or 7,
wherein the magnetic layer is a perpendicular magnetic recording layer.
10. A perpendicular magnetic recording medium,
wherein an adherent layer, a soft magnetic layer, a foundation layer, and a perpendicular magnetic recording layer are deposited on the glass substrate for the magnetic disc according to any of claims 1 to 9.