

MANUFACTURING METHOD OF GLASS SUBSTRATE
FOR
MAGNETIC RECORDING MEDIUM AND MAGNETIC RECORDING MEDIUM

The present disclosure relates to subject matters contained in Japanese Patent Application No. 2007-252668 filed on September 27, 2007, which are expressly incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001]

The present invention relates to a manufacturing method of a glass substrate for a magnetic recording medium used as a recording medium for a computer or the like and to a magnetic recording medium.

2. Description of the Prior Art

[0002]

Conventionally, as a substrate for a magnetic disc which is one of magnetic recording media used for a hard disc drive (HDD) or the like, an aluminum substrate has been widely used. 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 of the substrate surface and substrate strength to the aluminum substrate.

[0003]

One of the biggest issues of a magnetic disc using a glass substrate is high-precision cleaning of a glass substrate surface. If a foreign matter adheres on the glass substrate surface, a thin film formed on the glass substrate surface may be damaged. Moreover, if a magnetic disc using a glass substrate with a foreign matter adhered on the surface thereof is caused to reproduce data in a condition where flying height of a magnetoresistive head is lowered to improve recording density of the magnetic disc, there may be a case where an error occurs while reproducing or reproduction cannot be carried out.

[0004]

This is because a convex portion is formed on the magnetic disc surface due to a foreign matter (a glass particle or the like) on the glass substrate and the convex portion causes thermal asperity.

[0005]

Thermal asperity is a trouble which causes a reading error when a magnetoresistance element is heated by adiabatic compression of air or by contact by a magnetic head when the magnetic head is in float flight and passes above minute convex or concave portion on a magnetic disc surface. Therefore, extremely high-level of smoothness and flatness are required on the surface of a magnetic disc for a magnetoresistive head. Moreover, if a magnetic layer is formed while dust or a foreign matter adheres on the glass substrate surface, a convex portion is formed. Therefore, high-level cleaning to prevent dust and

to remove a foreign matter so that a convex or a concave portion is prevented is required for the glass substrate.

[0006]

A cause of the above-mentioned adherence of a foreign matter on the surface of a glass substrate for a magnetic disc is mainly damage (a crack or a chip) on a glass edge surface. The damage (a crack or a chip) on the glass edge surface occurs when the glass substrate is processed for shaping by a cutter or a drill. If the damage (a crack or a chip) remains on the edge surface of the glass substrate, the damage catches a particle and the particle thus caught may adhere on the surface of the glass substrate in the following process.

[0007]

Moreover, if there is damage on the edge surface of the glass substrate, strength of the glass substrate is decreased. That is, if small shock is applied to a glass substrate having damage (a crack or a chip) on an edge surface, there is a possibility that the glass substrate is broken from the damaged portion due to the shock.

[0008]

For the purpose of reducing such a damage on the edge surface, a technique to remove a damage from the edge surface of a glass substrate by polishing the edge surface with a rotary brush using abrasive compound including a loose grain after shaping the glass substrate has been proposed (e.g., Patent Document 1).

[Patent Document 1] Japanese Published Unexamined Patent

Application No. H11-221742

[0009]

However, according to the above-mentioned conventional method, the glass substrate is shape-processed by coring or scribe using a diamond electrodeposition grindstone or the like and in that case, cracks occur in various directions from the glass edge surface to inside of the glass. In the following forming of a chamfering surface, because chamfering is carried out by use of a diamond grain, cracks also occur in various directions from the chamfering surface at that time.

[0010]

It is difficult to completely remove cracks thus occurred in various directions in the polishing process by a rotary brush. Especially, it is impossible to sufficiently polish a chamfering surface by a rotary brush.

[0011]

Each step in the conventional method will be explained below. First, shape processing of a glass by coring or scribe will be explained. Fig. 6 is a view for explaining processing to cut a hole at the center portion of a disc-shaped glass substrate 71 using a core drill. A hole is cut in the glass substrate 71 by a cylindrical core drill 73 having a grindstone 72 at the tip to which diamond grain is electrodeposited. FIG. 6 (a) is a plane view seen from above, while FIG. 6 (b) is a cross-sectional view on a surface through the center of the glass substrate 71 and perpendicular to a main surface of the glass substrate 71. Coring is to spin the core drill 73 and

cut glass by the grindstone 72 to form a hole in the glass substrate 71. An enlarged view of the grindstone 72 when glass is cut is shown in FIG. 6 (c). When a glass is cut by a core drill, cracks 74 occur in various directions inside the glass. Here, when outer circumference of the glass substrate 71 is cut, the glass is cut by a glass cutter or the like having a grindstone at the tip in a similar manner and therefore cracks occur in various directions inside the glass during processing.

[0012]

Next, shape processing of a glass by a scribe will be explained. FIG. 7 is a view for explaining processing to cut a hole at the center portion of a disc-shaped glass substrate 71 by a scribe using a grindstone. In the glass substrate 71, cracks are made along the shape of the hole by a grindstone 75 to which diamond grain is electrodeposited. FIG. 7 (a) is a plane view seen from above, while FIG. 7 (b) is a cross-sectional view on a surface through the center of the glass substrate 71 and perpendicular to a main surface of the glass substrate 71. After cracks are made in the glass substrate 71 along the shape of the hole by the grindstone 75, glass at the portion where the hole is made is removed by hot press. An enlarged view of the grindstone 75 when cracks are made is shown in FIG. 7 (c). When cracks are made, cracks 74 occur in various directions inside the glass.

[0013]

As described above, in the processing of a glass by normal coring or scribe using a grindstone, cracks occur in various

directions inside of the glass.

[0014]

Next, chamfering processing using diamond grain will be explained using FIGs. 8 and 9. A forming step to carry out chamfering on the edge surface of a glass substrate is carried out to a ring-shaped glass substrate 80 on which a hole 81 is formed at the center of a disc-shaped glass substrate. A cross-sectional view on a surface through the center of the ring-shape and perpendicular to a main surface is shown in FIG. 8 (a).

[0015]

As shown in FIG. 8 (b), an inner side grindstone 90 is inserted into the hole 81 as a polishing means and an outer side grindstone 91 as a polishing means is also provided on the outer side of the glass substrate 80. The inner side grindstone 90 and the outer side grindstone 91 press the glass substrate 80 in a manner (not shown) that the grindstones sandwich the glass substrate 80 in radial direction. The inner side grindstone 90 and the outer side grindstone 91 are pulley type rotary grindstones and includes a later-described polishing surface on the outer circumference surface. The glass substrate 80, the inner side grindstone 90, and the outer side grindstone 91 are rotary driven by a drive means (not shown) and the rotation direction of each of them is set to be opposed at contact points of each of them. Here, a supporting mechanism and a rotary driving mechanism of the glass substrate 80 are not shown in the figures.

[0016]

Then, an inner edge surface 82 and an outer circumference edge surface 83 of the glass substrate 80 are cut to form chamfering portions 82a and 83a, as shown in FIG. 8 (c).

[0017]

FIG. 9 is a partially enlarged view of a polishing position. Because explanation on the inner side grindstone 90 and the outer side grindstone 91 overlap, only the outer side grindstone 91 will be explained here. On an outer circumference surface of a base material 91a of the outer side grindstone 91, a center plane portion 92a for forming a plane portion in a center portion in thickness direction of the outer circumference edge surface 83 and a sloping portion 92b for forming a chamfering portion 83a are formed. On the surface layers of the center plane portion 92a and the sloping portion 92b, diamond grain 93 as an example of a grain is buried in a nickel 94. By the grain 93, surface of the glass substrate 80 is polished. In the chamfering processing, cracks 95 occur in various directions of the inside of the glass from the sloping portion 92a of the outer side grindstone 91 in the chamfering portions 82a and 83a.

[0018]

Next, polishing by a rotary brush will be explained. FIG. 10 is a view explaining an edge surface polishing apparatus of a substrate. A glass substrate 101 is chamfered in the previous forming step and a side wall portion 111 and a chamfering portion 112 are already formed on an edge surface 110.

[0019]

As shown in FIG. 10, a plurality of glass substrates 101 are laminated to be retained in a columnar manner. A polishing brush 102 includes a nylon fiber and an external form thereof is approximately columnar shape, while an outer circumference surface thereof is a polishing surface. Rotation axes of the glass substrate 101 and the polishing brush 102 are approximately parallel and are caused to be rotated in the same direction (CCW in the figure: counterclockwise), which causes the glass substrate 101 and the polishing brush 102 to move in opposed directions at the contact portion so that an edge surface of the glass substrate 101 is polished by the polishing brush 102. Moreover, at the contact portion of the glass substrate 101 and the polishing brush 102, a nozzle 103 is closely positioned and an abrasive compound including a loose grain is provided.

[0020]

FIG. 11 is a partially enlarged view of a polishing position. As shown in FIG. 11, there may be a case where mirror polishing is not sufficiently carried out because the polishing brush 102 does not reach deep into a groove 112a formed by an adjacent chamfering portion 112. It is considered that this is because a fiber 120 of the polishing brush 102 can hardly reach deep into the groove. If mirror polishing is insufficient, an effect to prevent generation of dust or suction of a particle is decreased and that may be a cause of generation of thermal asperity if the glass substrate is used as a magnetic disc.

[0021]

As described above, it is impossible to sufficiently remove a damage (a crack or a chip) on the edge surface by a conventionally used method of shape-processing a glass substrate by coring or scribe using a grindstone, chamfering by diamond grain, and polishing the edge surface of the glass substrate by a rotary brush using an abrasive compound including a loose grain.

[0022]

Moreover, along with the high recording density and diversification of use of a magnetic disc in recent years, a smaller magnetic disc has been used. For example, in a small glass substrate used for a 1.8-inch magnetic disc, a hole in the center portion thereof also becomes smaller and therefore, it is difficult to appropriately mirror-polish an inner circumference edge surface thereof by a rotary brush. Moreover, because a small-size magnetic disc becomes thinner, it is more difficult for the fiber 120 of the polishing brush 102 in FIG. 11 to reach deep into the groove and it becomes more difficult to carry out appropriate mirror polishing.

[0023]

Further, along with the diversification of use of a magnetic disc, higher quality in a level different from that of the conventional one is required of a glass substrate for a magnetic disc. For example, in a magnetic disc of a high speed rotation type with a rotation number of 5400 rpm or more or a magnetic disc used for a mobile phone or the like which may be damaged when used, even a smaller damage becomes a problem

because the damage may become larger when used. In addition, the glass substrate becomes thinner in a small-size magnetic disc. If the glass substrate becomes thinner, a smaller damage may cause breakage. Therefore, for example, a damage (a crack or a chip) which was not be conventionally regarded as defective is now regarded as a problem and higher quality is required.

SUMMARY OF THE INVENTION

[0024]

The present invention aims at providing a manufacturing method of a glass substrate for a magnetic recording medium having a high glass strength by reducing a damage (a crack or a chip) on an edge surface to reduce a foreign matter on a main surface and a magnetic recording medium, which uses a glass substrate manufactured by the manufacturing method, to reduce thermal asperity.

[0025]

To achieve the above-mentioned purposes, inventors of the present invention thought that instead of shape-processing by coring or scribe using a grindstone used in the conventional method by which cracks are caused to occur in various directions from an edge surface of a glass when shape-processing is carried out, a crack must be caused to occur only in a direction to be cut when cutting a glass. As a result, the inventors decided to use laser to cause a crack to occur in a direction orthogonal to a main surface of a glass substrate and to cut the glass substrate. Thus, it became possible to prevent cracks from

occurring in various directions from an edge surface of the glass to inside of the glass when shape-processing is carried out. Moreover, chamfering is carried out without polishing by use of diamond grain. Instead, spherical center polishing is carried out to form a chamfering surface. This enables to prevent cracks in various directions inside of the glass when chamfering processing is carried out.

[0026]

That is, a manufacturing method of a glass substrate for a magnetic recording medium according to the present invention is characterized by laser processing a glass plate to form the shape of a glass substrate and at the same time to form an edge surface of the glass substrate.

[0027]

According to this method, it becomes possible to prevent cracks from occurring from the edge surface of the glass to various directions inside the glass and to reduce a damage (a crack or a chip) on the edge surface. Therefore, it becomes possible to reduce foreign matters on the main surface caused by a particle caught by the damage on the edge surface and at the same time to obtain a glass substrate for a magnetic recording medium having high glass strength.

[0028]

In the above-mentioned manufacturing method of a glass substrate for a magnetic recording medium, a chamfering surface may be formed on an edge surface of the glass substrate by spherical center polishing. According to this method, cracks

in various directions inside the glass can be prevented when chamfering and therefore this method is more preferable.

[0029]

The magnetic recording medium of the present invention includes a glass substrate for a magnetic recording medium manufactured by the above-mentioned manufacturing method of a glass substrate for a magnetic recording medium and a magnetic layer formed directly or via another layer on the glass substrate.

[0030]

According to this magnetic recording medium, it is possible to use a glass substrate for a magnetic recording medium having no damage on an edge surface thereof. Therefore, it becomes possible to reduce thermal asperity caused by a foreign matter on a main surface and to provide a magnetic recording medium having high strength.

[0031]

In the manufacturing method of a glass substrate for a magnetic recording medium according to the present invention, a crack is caused to occur by use of laser in a direction orthogonal to a main surface of the glass substrate. Moreover, regarding chamfering processing, a chamfering surface is formed by spherical center polishing.

[0032]

As a result, cracks are prevented from occurring from the edge surface of the glass to various directions inside the glass when shape processing or chamfering of the glass substrate is

carried out and it becomes possible to reduce damage (a crack or a chip) on the edge surface. Therefore, it becomes possible to reduce foreign matters on the main surface caused by a particle caught by the damage on the edge surface and at the same time to obtain a glass substrate for a magnetic recording medium having high glass strength. Moreover, because foreign matters on the main surface are reduced in the magnetic recording medium using the glass substrate, it becomes possible to reduce thermal asperity.

BRIEF DESCRIPTION OF THE DRAWINGS

The various features of novelty which characterize the invention are pointed out with particularity in the claims attached to and forming a part of this specification. For a better understanding of the invention, its operating advantages, and specific objects attained by its use, reference should be had to the accompanying drawing and descriptive matter in which there is illustrated and described a preferred embodiment of the invention.

[FIG. 1] A view for showing an external view of a magnetic disc in an embodiment of the present invention.

[FIG. 2] A view for explaining a laser scribe in the embodiment of the present invention.

[FIG. 3] A view for explaining a spherical center polishing apparatus in the embodiment of the present invention.

[FIG. 4] A view for explaining a glass plate of the present invention.

[FIG. 5] A view showing an external view of a transverse rupture strength test apparatus in the embodiment of the present invention.

[FIG. 6] A view for explaining shape processing of a glass substrate using a conventional core drill.

[FIG. 7] A view for explaining shape processing of a glass substrate using a conventional scribe.

[FIG. 8] A view for explaining conventional chamfering processing of a glass substrate.

[FIG. 9] A view for explaining conventional chamfering processing of a glass substrate.

[FIG. 10] A view for explaining a conventional edge surface polishing apparatus for a glass substrate.

[FIG. 11] A view for explaining a conventional edge surface polishing apparatus for a glass substrate.

The Best Mode for Carrying Out the Claimed Invention

[0033]

Hereinafter, an embodiment of the present invention will be explained in detail with reference to attached figures. Here, in the following explanation, a case where a glass substrate manufactured by a manufacturing method of a glass substrate for a magnetic recording medium according to the embodiment of the present invention (hereinafter simply referred to as a "glass substrate") is applied to a substrate for a magnetic disc which is one of magnetic recording media used for a hard disc drive (HDD) or the like will be shown. However, the present invention

is not limited thereto.

[0034]

FIG. 1 is a view explaining structure of a glass substrate manufactured by the manufacturing method of a glass substrate according to the embodiment of the present invention. In FIG. 1, a glass substrate which is a base of a magnetic disc used for a magnetic recording medium such as a hard disc drive (HDD) is shown. As shown in FIG. 1, a glass substrate 11 is a ring-shaped glass on which a round-shaped hole (hereinafter simply referred to as a "hole") 12 is formed at the center of a disc-shaped glass substrate. On an outer circumference portion 13 of the glass substrate 11, a plane surface 14 and a chamfering surface 15 are formed. Similarly, on an inner circumference portion 16, a plane surface 17 and a chamfering surface 18 are formed.

[0035]

Details of the manufacturing method of a glass substrate for a magnetic recording medium according to the embodiment of the present invention will be described later. However, to tell the outline of the method, the method includes: (1) a wrapping step (a step to make up thickness of glass plates. Depending on the necessity, this step includes a first and a second wrapping steps); (2) an edge surface forming step (a step for forming a final edge surface of the glass substrate for a magnetic recording medium by shape-processing and chamfering-processing the glass plate to produce a ring-shaped glass substrate); (3) a surface polishing step (first and second

polishing steps); and (4) a chemical strengthening step (depending on the necessity).

[0036]

In the manufacturing method of a glass substrate according to the embodiment of the present invention, shape processing is carried out by use of a laser scribe in the edge surface forming step to form final edge surfaces of plain surfaces 14 and 17 to obtain final edge surfaces of chamfering surfaces 15 and 18. Hereinafter, the edge surface forming step will be explained.

[0037]

Principle of a laser scribe used in the shape processing of a glass plate in the manufacturing method of a glass substrate for a magnetic recording medium according to the embodiment of the present invention will be explained using a figure.

[0038]

FIG. 2 shows a schematic diagram of an apparatus for cutting the glass by the laser scribe. The apparatus includes a laser 23 for irradiating laser beam to a glass plate 21 to be cut, a refrigerant jet 25 for cooling a surface of the glass plate 21, and a moving means for retaining the glass plate 21 and moving the glass plate 21 to a predetermined direction on one plane surface (not shown). The refrigerant jet 25 is provided to cool a portion of the surface of the glass plate 21 where laser beam is irradiated when the glass plate 21 moves.

[0039]

To cut the glass plate 21 by use of this apparatus, a

trigger crack 22 which triggers scribe is formed by a cutter wheel or the like at a point on the glass plate 21 where cutting is started and laser 23 is irradiated to that point. If the glass plate 21 is moved to the direction of an arrow A in that condition, a laser spot 24 which is an area where laser beam is irradiated from the laser 23 moves on the glass plate 21. The area which was heated by the irradiation of the laser beam is cooled by the refrigerant jet 25 to generate change in internal distortional stress in the glass plate 21 and thermal distortion occurs.

[0040]

Due to this thermal distortion, a crack (perpendicular crack) is generated by the trigger crack 22 in the direction perpendicular to the surface of the glass plate 21. The perpendicular crack grows along the trajectory of the laser spot 24 on the glass plate 21 along with the move of the glass plate 21 and a scribe line 26 (line of the perpendicular crack) is generated.

[0041]

If the glass substrate is cut after forming a perpendicular crack by this method, there occurs no crack (damage) on the edge surface of the glass substrate. Therefore, polishing on the edge surface is not necessary and the edge surface can be used as a final edge surface of a glass substrate for a magnetic recording medium.

[0042]

To process the substrate to be disc-shaped, trajectory

of the laser spot may be moved roundly with a predetermined diameter on the glass plate 21. An example where the laser 23 is fixed and the glass plate 21 is moved was shown, however, the glass plate 21 may be fixed and the laser 23 may be moved. As the laser 23 a CO₂ laser or the like is used.

[0043]

Next, a spherical center polishing apparatus for forming a chamfering surface will be explained. FIG. 3 is a view for explaining a spherical center polishing apparatus used for forming a chamfering surface of a glass substrate in the manufacturing method of a glass substrate for a magnetic recording medium according to the embodiment of the present invention.

[0044]

In the spherical center polishing apparatus shown in FIG. 3 (a), a holder spindle 52 retained by a holder shaft 51 through an outer ring collar 51a, an inner ring collar 52a, a bearing 51b, and the like is fixed to a holder 53. On the lower end portion of the holder 53, a ring-shaped elastic material 54 such as an O-ring or a V-ring is provided and the elastic material 54 is in contact with a substrate holder 56 retaining a glass substrate 55 through a sheet 57.

[0045]

A polishing plate 61 including a diamond pellet or a polyurethane sheet is connected with a tool adapter 62 and a shaft adapter 63 and is fixed to a tool spinning spindle (not shown). The polishing plate 61 is rotary driven in the

direction shown by an arrow 64 by the tool spinning spindle and is reciprocally moved in the direction shown by an arrow 65 with the spherical center of the formed spherical surface as center of reciprocal movement.

[0046]

If the polishing plate 61 of the spherical center polishing apparatus thus configured is reciprocally moved in the direction shown by the arrow 65 while rotating in the direction shown by the arrow 64, the polishing plate does not come into contact with a main surface and outer circumference edge surface of the glass substrate 55 and only an angle made between the main surface and outer circumference edge surface of the glass substrate 55 is polished to form a chamfering surface because the glass substrate 55 to be processed is plane to a processing spherical surface R of the polishing plate 61. If polishing on one side is finished, the glass substrate may be turned back so that chamfering surface may be formed on the other side.

[0047]

To form a chamfering surface on the inner circumference edge surface, a polishing plate 67 shown in FIG. 3 (b) including a diamond pallet or a polyurethane sheet on external side of spherical surface may be prepared as the polishing plate 61 so that polishing is carried out on the external side of the spherical surface.

[0048]

If the chamfering surface is formed by the spherical

center polishing in such a manner, cracks do not occur inside the glass in various directions when chamfering processing is carried out.

[0049]

Here, it is preferable that the chamfering surface is formed by the spherical center polishing after shape processing by a laser scribe. However, the chamfering surface may not be formed. Because the edge surface formed by the laser scribe has no damages, polishing thereof is not required. In that case, the chamfering surface forming step can be omitted and the number of steps can be reduced.

[0050]

Next, a magnetic recording medium according to the present invention will be explained. The magnetic recording medium of the present invention includes at least a magnetic layer formed on the glass substrate manufactured by the above-mentioned manufacturing method of a glass substrate.

[0051]

In the magnetic recording medium of the present invention, since there is no damage (a crack or a chip) on the edge surface of the glass substrate, it becomes possible to reduce thermal asperity as well as to manufacture a magnetic recording medium having high glass strength.

[0052]

The magnetic recording medium is normally manufactured by sequentially laminating a foundation layer, a magnetic layer, a protection layer, and a lubrication layer on a glass substrate.

Moreover, the magnetic recording medium is normally manufactured by sequentially laminating a foundation layer, a magnetic layer, a protection layer, and a lubrication layer on a glass substrate which has predetermined flatness and surface roughness and is chemically strengthened depending on the necessity. Here, the foundation layer of the magnetic recording medium of the present invention is appropriately selected depending on the magnetic layer.

[0053]

As the foundation layer, a foundation layer including at least one of nonmagnetic metals selected from, for example, Cr, Mo, Ta, Ti, W, V, B, and Al, can be used. In case of the magnetic layer including Co as main component, it is preferable that the magnetic layer includes only Cr or Cr alloy from viewpoint of improving magnetic characteristics. Moreover, the foundation layer is not limited to a single layer and may be multi-layered structure including laminated same or different layers. For example, multi-layered foundation layer such as Cr/Cr, Cr/CrMo, Cr/CrV, CrV/CrV, Al/Cr/CrMo, Al/Cr/Cr, Al/Cr/CrV, and Al/CrV/CrV can be the foundation layer.

[0054]

Material of the magnetic layer of the magnetic recording medium of the present invention is not especially limited. As the magnetic layer, for example, CoPt, CoCr, CoNi, CoNiCr, CoCrTa, CoPtCr, and CoNiPt including Co as main component, or magnetic thin film such as CoNiCrPt, CoNiCrTa, CoCrTaPt, and CoCrPtSiO can be used. The magnetic layer may have a

multi-layered structure (e.g., CoPtCr/CrMo/CoPtCr, CoCrTaPt/CrMo/CoCrTaPt, or the like) aiming at reduction of noise by dividing a magnetic film by a nonmagnetic film (e.g., Cr, CrMo, CrV, or the like).

[0055]

A magnetic layer corresponding to a magnetoresistive head (MR head) or a giant magnetoresistive head (GMR head) includes impurity element selected from Y, Si, rare earth element, Hf, Ge, Sn, and Zn or oxide of these impurity elements to be included in Co system alloy. Moreover, other than the above, the magnetic layer may include a granular film having a structure that magnetic particles such as Fe, Co, FeCo, and CoNiPt are dispersed in a nonmagnetic film including ferrite system, metal-rare earth system, SiO₂, or BN. Further, the magnetic layer may be one used for longitudinal recording or for perpendicular recording.

[0056]

The protection layer in the magnetic recording medium of the present invention is not especially limited. The protection layer includes, for example, a Cr film, a Cr alloy film, a carbon film, a zirconia film, a silica film and the like. These protection films can be sequentially formed by an in-line type sputtering device together with the foundation layer, the magnetic layer, and the like. Moreover, the protection layers may be single-layered or multi-layered having same or different films.

[0057]

In the present invention, another protection layer may be formed on or instead of the protection layer. For example, instead of the protection layer, a silicon oxide (SiO_2) film may be formed by dispersing colloidal silica molecules in tetraalkoxylan which is diluted by alcohol series solvent, applying it on a Cr film, and burning it.

[0058]

The lubrication layer in the magnetic recording medium of the present invention is not especially limited. The lubrication layer is formed by, for example, diluting perfluoropolyether (PFPE) which is liquid lubricant agent by freon system solvent, applying the diluted lubricant agent on the surface of a medium by dipping method, spin coat method, or spray method, and depending on the necessity, carrying out heat processing.

[0059]

As described above, in the magnetic recording medium according to the present invention, a glass substrate manufactured by the above-mentioned manufacturing method of a glass substrate for a magnetic recording medium according to the present invention is used. Therefore, it is possible to reduce generation of thermal asperity and to manufacture a magnetic recording medium having high glass strength.

[0060]

[Embodiment]

Hereinafter, an embodiment carried out to clarify the effect of the present invention will be explained. In the

present embodiment, a glass substrate for a magnetic recording medium and a magnetic disc were manufactured by the following steps. In the following explanation, an example where a 2.5-inch glass substrate for a magnetic recording medium and a magnetic disc are manufactured will be explained. However, the present invention is not especially limited thereto and may be applied to a 1.8-inch or 3.5-inch glass substrate and a magnetic disc.

[0061]

(1) First Wrapping Step

First, a multicomponent glass plate including amorphous glass was prepared. Type of the glass is aluminosilicate glass. The glass plate was formed by float method and has a sheet shape with the size of 150 x 150 x 0.8 mm.

[0062]

Next, both main surfaces of the sheet-shaped 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 sheet-shaped glass, grinding fluid containing loose grain is supplied on the main surface of the sheet-shaped 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.

[0063]

(2) Edge surface forming step

This step is for shape processing the glass plate to be a ring-shaped glass substrate and for forming a final edge surface of the glass substrate for a magnetic recording medium. This step includes an external shape forming step by a laser scribe (2-1) and a chamfering surface forming step by spherical center polishing (2-2).

[0064]

(2-1) External shape forming step by laser scribe

A plane view of a glass plate after first wrapping is carried out is shown in FIG. 4. In the figure, an area 32, which is to be a main surface of a glass substrate for a magnetic disc, on the main surface of a glass plate 31 is surrounded by dotted lines and shaded. Principle of the laser scribe is described above referring to FIG.2.

[0065]

First, to draw a scribe line (line of perpendicular crack) along the outer circumference of the area to be a glass substrate, a trigger crack was made in a predetermined spot 33 on the outer circumference by a cutter wheel. Then, rotating the glass plate 31 with a center point 34 of the outer circumference as center of rotation, laser is irradiated from the point 33 where the trigger crack was made, the area heated by irradiation of laser is cooled by refrigerant jet to form a scribe line, and the process is finished when the line has drawn a circle. CO₂ laser was used as the laser, laser output was 70W, and moving speed of the substrate at the outer circumference was 100mm/sec.

[0066]

Then, the glass plate 31 is torn along the scribe line by hot pressing to cut out an area to be a glass substrate.
[0067]

Next, to form a hole of the glass substrate, a trigger crack was made in a predetermined spot 35 on the inner circumference of the area to be a glass substrate. Thereafter, similarly to the above, a scribe line was drawn along the inner circumference and the glass substrate was cut by hot pressing.
[0068]

In a case where external shape of the glass substrate is formed by the above-mentioned method, both edge surfaces of the outer and inner circumferences do not have a crack after shape processing and therefore polishing of the edge surfaces is not required and the edge surfaces can be used as final edge surfaces of a magnetic disc.
[0069]

Here in the present embodiment, laser was fixed and the glass plate was rotated. However, contrary to that, the glass plate may be fixed and the laser may be rotated.
[0070]

(2-2) Chamfering surface forming step by spherical center polishing

Forming of a chamfering surface was carried out by use of the spherical center polishing apparatus shown in FIG. 3 (a). First, to form a chamfering surface of the outer circumference edge surface, the glass substrate which was shape processed in the previous step was set on the substrate holder 56 of the

spherical center polishing apparatus shown in FIG. 3 (a) and spherical center polishing was carried out. After polishing on one surface was over, the glass substrate was turned back and set on the substrate holder 56 again for carrying out chamfering surface forming for the back surface.

[0071]

Next, to carry out chamfering surface forming on the inner circumference edge surface, the polishing plate 61 of the spherical center polishing apparatus shown in FIG. 3 (a) is replaced by the polishing plate 67 shown in FIG. 3 (b) and polishing was carried out by external side of the sphere. After polishing on one surface was over, the glass substrate was turned back and set on the substrate holder 56 again for carrying out chamfering surface forming on the back surface.

[0072]

As described above, if a chamfering surface is formed by a spherical center polishing apparatus, only the corner between the main surface of the glass substrate and the edge surface can be polished and therefore it is possible to use a plane surface of the edge surface formed by the laser scribe in the previous step can be used as the final edge surface of the magnetic disc without processing. Moreover, because polishing is not carried out in the forming of the chamfering surface, a crack does not occur from the chamfering surface to the inside of the glass when processing.

[0073]

Thus, by the (2) edge surface forming step, the glass plate

was shape-processed to a ring-shaped glass substrate. Because external shaping was carried out by the laser scribe and the chamfering surface was formed by spherical center polishing, a crack does not occur in the plane surface and chamfering surface on the edge surface and therefore further polishing is not needed. Therefore, the edge surface formed by this step can be used as the final edge surface of the magnetic disc.

[0074]

(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 edge surface forming 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.

[0075]

(4) Main surface polishing step

As a main surface polishing step, the first polishing step was carried out. The first polishing step was carried out to the glass substrate after the above-mentioned edge surface forming and is mainly aimed at removing crack or distortion remaining on the main surface after the wrapping step. A preliminary polishing step was carried out by an apparatus which can polish both surfaces. A hard urethane pad including zirconium oxide and cerium oxide in advance was used as a

polishing pad.

[0076]

Polishing liquid was prepared by mixing water and cerium oxide abrasive grain having an average particle size of $1.2 \mu\text{m}$. Here, it is preferable that the particle size of the abrasive grain is in a range between 1.0 and $1.4 \mu\text{m}$. Any abrasive grain having a particle size of $4 \mu\text{m}$ or more was removed in advance. When the polishing liquid was measured, the maximum value of an abrasive grain included in the polishing liquid was $3.5 \mu\text{m}$, an average particle size of the abrasive grain was $1.2 \mu\text{m}$, and D50 value was $1.1 \mu\text{m}$. Load applied to the glass plate was set to between $80\text{g}/\text{cm}^2$ and $100\text{g}/\text{cm}^2$ and removal thickness of the surface portion of the glass plate was set between 20 and $40 \mu\text{m}$.

[0077]

The glass substrate after the first polishing step was sequentially dipped in cleansing tanks of neutral detergent, pure water (1), pure water (2), isopropyl alcohol (IPA), and IPA (steam drying) to be cleansed.

[0078]

Next, second polishing step (mirror polishing step) was carried out as the main surface polishing step. The second polishing step is aimed at polishing the glass plate more so that the surface of the glass plate has a mirror surface. In the second polishing step, main surface was mirror-polished by the apparatus for both surfaces polishing including planetary gear mechanism, using a polishing pad including polyurethane

soft polisher. Polishing liquid was prepared by mixing ultrapure water and colloidal silica grain having a grain particle of 40nm.

[0079]

The glass plate after the second polishing step was sequentially dipped in cleansing tanks of neutral detergent (1), neutral detergent (2), pure water (1), pure water (2), isopropyl alcohol (IPA), and IPA (steam drying) to be cleansed. Here, ultrasonic wave was applied to the tanks.

[0080]

(5) 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 potassium nitrate (60%) and sodium nitrate (40%) were mixed. The chemical solution was heated to 380 °C. Then, the cleansed glass substrate was dipped into the chemical strengthening solution for about 4 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.

[0081]

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 about 100 μm .

[0082]

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 sulfuric acid is sequentially dipped into tanks of pure water (1), pure water (2), isopropyl alcohol (IPA), and IPA (steam drying) to be cleansed. Here, ultrasonic wave was applied to the tanks.

[0083]

As described above, by carrying out the first wrapping step, the edge surface forming step, the second wrapping step, the main surface polishing step (the first and second polishing steps), and the chemical strengthening step, a glass substrate for a magnetic disc having no damage on the edge surface and having high rigidity was obtained.

[0084]

(6) Precise cleansing step

Next, precise cleansing of the glass disc was carried out. This step is for removing residue of polishing compound which may cause head crash or thermal asperity and for obtaining a clean glass substrate having a flat surface. The precise cleansing step includes following cleansing steps.

[0085]

First, a cleansing step by cleansing compound was carried out. Alkaline solution was used as the cleansing compound. The glass disc was dipped in the cleansing compound and was washed for two minutes while reciprocally moved. At this time, the temperature of the cleansing compound was set to 50°C and ultrasonic wave was applied to increase cleansing effect.

[0086]

Next, water rinse cleansing step was carried out for two minutes. This is for removing the residue of the cleansing compound used in the above-mentioned cleansing. Then, IPA cleansing step was carried out for two minutes. This is for cleansing the glass disc, as well as removing water on the glass substrate. Finally, IPA steam drying step was carried out for two minutes. This is to dry the glass substrate while removing the liquid IPA which adheres on the glass substrate by IPA steam.

[0087]

(7) Magnetic disc manufacturing method

A seed layer, a Cr foundation layer, a CrMo foundation layer, a CoPtCrTa magnetic layer, and a carbon hydride protection layer were formed on both sides of the glass substrate obtained through the above-mentioned steps by a single type sputtering device and a perfluoropolyether lubricant layer was formed by dip method to manufacture a magnetic disc.

[0088]

[Comparative Example 1]

Here, for the purpose of comparison with the above-mentioned embodiment, a glass substrate was manufactured by executing an edge surface forming step according to a conventional method as a comparative example 1. That is, the outer circumference of the glass substrate was processed by a cutter using diamond grain and the hole in the center portion was processed by a core drill using diamond grain. Subsequently, the inner circumference edge surface and the outer circumference edge surface of the ring-shaped glass substrate obtained by the above-mentioned processing were polished by a rotary brush using abrasive compound including a loose grain. Except for the edge surface forming step, all the steps were the same as those in the present embodiment. However, the chemical strengthening step was not carried out for the comparative example 1.

[0089]

[Comparative Example 2]

Next, as a comparative example 2, a glass substrate was manufactured by carrying out the chemical strengthening step to a glass substrate manufactured by the method of the comparative example 1. The chemical strengthening step was carried out under the same condition as the embodiment.

[0090]

[Surface observation]

Edge surface and main surface of a glass substrate for a magnetic recording medium manufactured by the manufacturing method of a glass substrate for a magnetic recording medium

according to the present embodiment and glass substrate manufactured by the comparative examples 1 and 2 were observed. Regarding the present embodiment, a glass substrate to which chemical strengthening processing was not carried out (embodiment 1) and one to which chemical strengthening processing was carried out (embodiment 2) were manufactured and observed. Surface observation was carried out by use of an electronic microscope (magnification of 4000 power).

[0091]

As a result, no foreign matter or damage (a crack or a chip) could be found on both the outer circumference edge surface and the inner circumference edge surface of the glass substrate for a magnetic recording medium of the embodiments 1 and 2 and the edge surface was mirror surfaced. No foreign matter was found on the main surface of the glass substrate as well. This shows that in the case of the manufacturing method of a glass substrate for a magnetic recording medium according to the present embodiment, external shape was formed by a laser scribe and the chamfering surface was formed by spherical center polishing and therefore there is no damage on the edge surface and adherence of a particle on the main surface caused by the damage on the edge surface did not occur.

[0092]

When surface observation for comparative examples 1 and 2 was carried out, fine damages (cracks or chips) were found on the outer circumference edge surface and the inner circumference edge surface. Moreover, on the main surface of

the glass substrates, particles which may cause thermal asperity if magnetic discs are to be manufactured by use of the glass substrates were found.

[0093]

It is conceivable that this is because polishing on the outer circumference edge surface and the inner circumference edge surface of the comparative examples 1 and 2 was not sufficient, small damages remained on the edge surfaces, particles were caught by the damages, and the particles adhered on the surface in the steps that follow the polishing.

[0094]

[Transverse rupture strength test]

Further, transverse rupture strength was measured regarding the above-mentioned embodiments 1 and 2 and comparative examples 1 and 2 by use of a transverse rupture strength test apparatus shown in FIG. 5 (Shimadzu autograph DDS-2000). The transverse rupture strength test apparatus measures transverse rupture strength of a glass substrate 42 by placing the glass substrate 42 which is a target of the test on a substrate holder 41, placing a rigid sphere 43 on the hole of the glass substrate 42, and pressing from the top of the rigid sphere 43 via a load cell 44. Because only the outer circumference portion of the glass substrate 42 is supported by the substrate holder 41, the hole which is provided at the center is pressed from the above. Therefore, the glass substrate 42 is bent and as pressure is increased, the glass substrate 42 is broken when pressure reaches the breaking point

of the glass substrate. This pressure is regarded as the transverse rupture strength of the glass substrate 42.

[0095]

As a result of the above-mentioned transverse rupture strength tests conducted for the above-mentioned embodiments 1 and 2 and the comparative examples 1 and 2, even the embodiment 1 to which the chemical strengthening processing was not carried out showed higher transverse rupture strength than the comparative example 1 (no chemical strengthening processing) or the comparative example 2 (chemical strengthening processed). The embodiment 2 to which chemical strengthening processing was carried out showed higher transverse rupture strength than the embodiment 1.

[0096]

These results show that in the comparative examples 1 and 2 manufactured by the conventional method has fine damages on the edge surface as understood from the result of the surface observation and therefore even if chemically strengthened, a glass substrate having high strength could not be obtained.

[0097]

On the contrary, in the edge surface forming of the glass substrate of the present embodiments, since the external shape forming was carried out by a laser scribe and the chamfering surface was formed by spherical center polishing, there is no damage on the edge surface. Therefore, it was possible to obtain a glass substrate having high strength even before chemical strengthening processing.

[0098]

[Record reproduction test]

Next, magnetic discs were manufactured by use of the above-mentioned embodiments 1 and 2 and comparative examples 1 and 2 to conduct record reproduction tests. A magnetic head having a magnetoresistive element as a reproduction element part, a single magnetic element as a recording element part, and a floating amount of 8 nm was used for the record reproduction test. Recording method was perpendicular recording.

[0099]

As a result, it was confirmed that information could be recorded and reproduced correctly by the embodiments 1 and 2. At that time, no thermal asperity signal was detected and recording/reproduction could be carried out with 100-giga bit per 1 square inch. This shows that in the case of the embodiments 1 and 2, external shape was formed by a laser scribe and the chamfering surface was formed by spherical center polishing and therefore there is no damage on the edge surface and adherence of a particle on the main surface caused by the damage on the edge surface did not occur.

[0100]

On the other hand, thermal asperity signals were detected in reproduction signals of the comparative examples 1 and 2. From the result, it is considered that polishing on the outer circumference edge surface and the inner circumference edge surface of the comparative examples 1 and 2 was not sufficient, small damages remained on the edge surfaces, particles were

caught by the damages, and the particles adhered on the surface in the steps that follow the polishing.

[0101]

From the above-mentioned test results, it was confirmed that since shape processing by a laser scribe was adopted for external shaping of the glass substrate and spherical center polishing was adopted for chamfering surface forming in the manufacturing method of a glass substrate for a magnetic recording medium according to the present invention, there is no damage on the edge surface and therefore it becomes possible to reduce foreign matters caused by particles caught by the damage on the edge surface and to obtain a glass substrate for a magnetic recording medium having high glass strength.

[0102]

Moreover, it was confirmed that thermal asperity can be reduced because foreign matters on the main surface of the glass substrate can be reduced in the magnetic recording medium using the glass substrate of the present invention.

[0103]

Here, the present invention is not limited to the above-mentioned embodiment and can be executed by making appropriate changes. For example, in the present embodiment, an example where the chamfering surface is formed by spherical center polishing after shape processing by a laser scribe was shown. However, the chamfering surface need not be formed. Since the edge surface formed by a laser scribe has no damage on the surface, it is not necessary to polish it. In that case,

chamfering surface forming step can be omitted and the number of steps can be reduced.

[0104]

Further, an example where a CO₂ laser was used for the laser scribe was shown. However, the present invention is not limited thereto and a semi-conductor laser may be used.

[0105]

Further, materials, size, processing procedures, and the like in the above-mentioned embodiment are an example of the present invention and can be changed for execution of the present invention within a range where the effect of the present invention can be produced. Further, the present invention can be appropriately changed for execution without departing from the scope of the invention.

What is claimed is:

1. A manufacturing method of a glass substrate for a magnetic recording medium comprising a step of laser processing a glass plate to form an external shape of the glass substrate and at the same time to form an edge surface of the glass substrate.

2. The manufacturing method of a glass substrate for a magnetic recording medium according to claim 1,

wherein a chamfering surface is formed on the edge surface of the glass substrate by spherical center polishing.

3. A magnetic recording medium comprising a glass substrate for a magnetic recording medium manufactured by the manufacturing method of a glass substrate for a magnetic recording medium according to either claims 1 or 2 and a magnetic layer formed directly or via another layer on the glass substrate.

4.

A manufacturing method of a glass substrate for a magnetic recording medium including a chamfering surface between a main surface and an edge surface, comprising:

a step of generating a crack in the depth direction of a glass plate by cooling a part of the glass plate after the part is irradiated by laser;

a crack forming step of forming the crack roundly on the

main surface of the glass plate by moving an area where laser irradiation and cooling are carried out along the external shape of a glass substrate for a magnetic recording medium;

an extraction step of extracting a disc-shaped glass plate from the glass plate on the basis of the crack; and

a step of forming the chamfering surface on the disc-shaped glass plate.