

DESCRIPTION

MANUFACTURING METHOD OF A GLASS SUBSTRATE FOR A
MAGNETIC DISK AND
5 A MAGNETIC DISK

[Technical Field]

[0001]

The present invention relates to a manufacturing method of a glass
10 substrate for a magnetic disk installed in a magnetic disk device such as a
HDD (hard disk drive) or the like and a magnetic disk.

[Background Art]

[0002]

15 With advancement of information technology, information recording
technology, particularly magnetic recording technology, has progressed
remarkably. In a magnetic disk used for an HDD (hard disk drive) which
is one of the magnetic recording media and so on, rapid miniaturization,
production of thinner disk, increase in recording density and speedup of
20 access rate have been continued. The HDD performs recording and
playbacking while allowing a magnetic disk having a magnetic layer on a
discal substrate to rotate at a high rate and allowing a magnetic head to
fly floating above this magnetic disk.

[0003]

Higher substrate strength is demanded for a magnetic disk since the rotary rate of the magnetic disk increases with the increase of access rate. In addition, with the increase of recording density, the magnetic head changes from a thin film head to a magnetoresistive head (MR head),
5 further to a giant magnetoresistive head (GMR head), and the flying height from the magnetic disk of the magnetic head becomes narrower to around 8 nm. On this account, when there are irregularities on the magnetic disk surfaces, there may be caused crash failure due to collision of the magnetic head, thermal asperity failure which leads to read errors
10 due to heat caused by adiabatic compression of the air or contact thereof. It becomes important to finish the main surfaces of the magnetic disk as an extremely smooth surface to suppress such troubles caused on the magnetic head.

[0004]

15 Therefore, glass substrates have come to be used lately as substrates for a magnetic disk in place of conventional aluminum substrates. This is because the glass substrates consisting of glass, which is a rigid material, are superior to the aluminum substrates consisting of a metal, which is a flexible material, in smoothness of the substrate surfaces, substrate
20 strength and rigidity.

[0005]

Glass substrates used for these magnetic disks can be obtained by forming a discal glass substrate in which a round hole is disposed from a glass base material which is to become a base material, then a lapping step
25 (grinding), a polishing step, or the like is performed in sequence to this

discal glass substrate. Furthermore, in order to effectively suppress thermal asperity failure, edge faces of inner periphery and outer periphery are mirror-polished (for example, refer to Patent Document 1).

[0006]

5 As a process to dispose a round hole in a glass substrate, a process is known wherein after a cut is formed on a glass substrate, the hole is punched by using a pushing bar (for example, refer to Patent Document 2). In the polishing step, etc. after the round hole is formed, it is preferred that as few cracks or chips as possible are produced on an edge face of the
10 round hole when the round hole is formed.

[Citation List]

[Patent Literature]

[0007]

15 [Patent Literature 1] Japanese Patent Laid-Open No. 2007-197235
 [Patent Literature 2] Japanese Patent Laid-Open No. 2006-99857

[Summary of Invention]

[Technical Problem]

20 [0008]

 However, when a round hole is formed by punching a portion in a glass substrate by a pushing bar, etc., there may be generated chipping by strongly coming into contact with the edge face of the round hole when the glass that is to be punched falls out (refer to FIG. 8). When a cut line is
25 made in a diagonal direction to the surface of the glass substrate to be

punched, it is possible to suppress generation of chipping to some extent. However, the edge face of the round hole obtained also becomes a diagonal shape, and depending on the angle of the cut line, there is a problem in that chamfering processing of an inner hole and a polishing process of an inner peripheral edge face may become complex.

Particularly, in the case of a 2.5 inch glass substrate for a magnetic disk, since the diameter of the inner hole is extremely small, around 20 mm, if an inner peripheral edge face which is difficult to perform processing is diagonal, in the chamfering and polishing processes a load is applied to the inner peripheral edge face, making precise processing difficult to perform. In addition, if a load is applied to the inner peripheral edge face and a minor crack is generated on the inner peripheral edge face, when the glass substrate for a magnetic disk is used as a thermal assist magnetic disk, for example, sudden heating and cooling during the formation of the magnetic layer develop a crack, presenting a problem in that it destroys the magnetic disk.

As a result, it is preferred that when a round hole is formed by punching a portion of a glass substrate, the edge face of the round hole is in a perpendicular direction that is substantially perpendicular to the main surface of the glass substrate, and cracks or chips are generated on the edge face of the round hole as few as possible.

[0009]

The present invention has been accomplished in consideration of the above problem. In the manufacturing method of a substrate for a magnetic disk having a round hole, even when a round hole is formed by

punching a cut line formed in a perpendicular direction that is substantially perpendicular to the main surface of the glass substrate, an object thereof is to suppress generation of chipping near the round hole in the glass substrate.

5

[Solution to the Problem]

[0010]

One aspect of the manufacturing method of a glass substrate for a magnetic disk according to the present invention is a manufacturing method of a glass substrate for a magnetic disk comprising a step of forming a round hole in a glass substrate, wherein the step of forming the round hole comprises a first step of, for one of main surfaces of the glass substrate, forming a cut line that is to form a periphery of a region that is to become the round hole in a perpendicular direction that is substantially perpendicular to the main surface of the glass substrate; a second step of causing the cut line to reach the other main surface of the glass substrate; and a third step of, by causing a pushing body to come into contact and to apply force in the perpendicular direction from one of the main surfaces to a glass portion that is to be separated from the glass substrate to become a round hole, forming a round hole in the glass substrate by separating the glass portion; wherein in the third step, the glass portion is separated from the glass substrate so as not to allow the pushing body to protrude from the other main surface.

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15

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[0011]

It is preferred that in one aspect of the manufacturing method of a glass substrate for a magnetic disk according to the present invention, the distance which the pushing body applies force to the glass portion that is to be separated in the perpendicular direction is smaller than the
5 thickness of the glass substrate.

[0012]

It is preferred that in one aspect of the manufacturing method of a glass substrate for a magnetic disk according to the present invention, the distance which the pushing body applies force to the glass portion that is
10 to be separated in the perpendicular direction is controlled by a bias mechanism to control movement of the pushing body, and the bias mechanism reverses bias force applied to the pushing body during a period from a time when the pushing body comes into contact with the glass portion that is to be separated to a time when the glass portion is
15 separated.

[0013]

One aspect of the manufacturing method of a glass substrate for a magnetic disk according to the present invention is a manufacturing method of a glass substrate for a magnetic disk comprising a step of
20 forming a round hole in a glass substrate, wherein the step of forming the round hole comprises a first step of, for one of main surfaces of the glass substrate, forming a cut line that is to form a periphery of a region that is to become the round hole in a perpendicular direction that is substantially perpendicular to the main surface of the glass substrate; a second step of
25 causing the cut line to reach the other main surface of the glass substrate;

and a third step of, by spraying a gas and applying force in the perpendicular direction to a glass portion that is to be separated from the glass substrate to become a round hole, forming the round hole in the glass substrate by separating the glass portion; wherein a period to spray the gas to the glass portion that is to be separated is made shorter than a period from a time when the gas comes into contact with the region that is to become the round hole to a time when the glass portion that is to become the round hole is separated from the glass substrate.

[0014]

10 It is preferred that in one aspect of the manufacturing method of a glass substrate for a magnetic disk according to the present invention, in the third step, a direction to separate the glass portion from the glass substrate is downward in a perpendicular direction.

[0015]

15 It is preferred that in one aspect of the manufacturing method of a glass substrate for a magnetic disk according to the present invention, the second step of causing the cut line to reach the other main surface of the glass substrate is a step of heating other portion excluding a glass portion that is to be separated from the glass substrate to become the round hole.

20 [0016]

It is preferred that in one aspect of the manufacturing method of a glass substrate for a magnetic disk according to the present invention, the second step of causing the cut line to reach the other main surface of the glass substrate is a step of cooling the glass portion that is to be separated from the glass substrate to become the round hole.

[0017]

It is preferred that in one aspect of the manufacturing method of a glass substrate for a magnetic disk according to the present invention, a glass substrate is produced by a float process.

5 [0018]

It is preferred that in one aspect of the manufacturing method of a glass substrate for a magnetic disk according to the present invention, after the step of forming a round hole in a glass substrate, a step of performing chamfering processing is carried out on the glass substrate.

10 [0019]

Furthermore, the magnetic disk of the present invention has at least a magnetic layer which is formed on a main surface of a glass substrate for a magnetic disk that can be obtained by the above manufacturing method of a glass substrate for a magnetic disk.

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[Technical Advantage of the Invention]

[0020]

According to one aspect of the present invention, when punching is performed by causing a pushing body to come into contact with and apply force to a glass portion that is to become a round hole in a glass substrate, generation of chipping can be suppressed at an edge face of a round hole by separating the glass portion from the glass substrate so as not to allow the pushing body to protrude from the other main surface.

20

25 [Brief Description of the Drawings]

[0021]

FIG. 1 is a drawing illustrating one example of forming a round hole in a glass substrate according to an embodiment of the present invention.

FIG. 2 is a drawing illustrating one example of forming a round hole
5 in a glass substrate according to an embodiment of the present invention.

FIG. 3 is a drawing illustrating one example of forming a round hole in a glass substrate according to an embodiment of the present invention.

FIG. 4 is a drawing illustrating one example of forming a round hole by using a pushing body in which a bias mechanism is disposed in a glass
10 substrate according to an embodiment of the present invention.

FIG. 5 is a drawing illustrating one example of forming a round hole by spraying a gas on a glass substrate according to an embodiment of the present invention.

FIG. 6 is a drawing illustrating one example of a manufacturing
15 method of forming a glass substrate for a magnetic disk comprising a step of forming a round hole in a glass substrate according to an embodiment of the present invention.

FIG. 7 is a drawing illustrating one example of forming a round hole by using a pushing body in which a bias mechanism is disposed in a glass
20 substrate according to an embodiment of the present invention.

FIG. 8 is a drawing illustrating a process of forming a round hole in a glass substrate according to the prior art.

[Description of the Embodiments]

25 [0022]

In the following, embodiments of the present invention will be described by using drawings, working examples, etc. These descriptions exemplify the present invention and they do not limit the scope of the present invention. It goes without saying that any other embodiments
5 can belong to the scope of the present invention as far as they are compatible with the objects of the present invention.

[0023]

The present inventor performed the process of forming a round hole in a glass substrate. A cut line 202 that was to become a periphery of a
10 glass portion 201 that was to be separated to become a round hole in a glass substrate 200 and the glass substrate was kept horizontal. By causing a pushing body 203 to come into contact with and to apply force to the glass portion 201 to be separated in a perpendicular direction that is substantially perpendicular to the main surface of the glass substrate, the
15 glass portion 201 was punched. The present inventor discovered that chipping was easy to be generated at the edge face (inner peripheral edge face) of a round hole 205 on the surface 212 opposite to the surface 211 on which the pushing body 203 was caused to come into contact (refer to FIGS. 8(A)-(D)).

20 The present inventor performed further studies and came to the following conclusion. Since it was impossible to pressurize on a perfectly middle point of the round hole to punch on account of a precision issue, when the glass portion 201 that was to be separated to become the round hole fell off by being pushed by the pushing body 203, the pushing body
25 pushed backward and tilted the round hole to fall off. The glass substrate

of the round hole portion that was about to fall off came into contact, while it was tilted, with the edge face of the round hole 205 on the surface 212 of the glass substrate thereby chipping was generated.

[0024]

5 The present inventor learned that when the glass portion that was to be separated to become the round hole fell off, by performing punching of the glass substrate so that strong local force was not applied to the edge face of the round hole, generation of chipping could be suppressed at the inner peripheral edge face formed in the glass substrate. The step of
10 forming a round hole in a glass substrate (coring step) will be described below by referencing FIG. 1 to 5. FIG. 1 illustrates the upper surface of the glass substrate, and FIG. 2 to 5 illustrate the cut surface of the middle portion of the glass substrate.

[0025]

15 First, a glass substrate 100 is prepared (refer to FIG. 1(A), FIG. 2(A)). The glass substrate 100 may be processed into a disk shape in advance as illustrated in FIG. 1(A), or as illustrated in FIG. 6, may be
processed into a disk shape by forming a cut line 123 that is to become a peripheral edge of a region 122 that is to become a disk shape in a sheet
20 glass substrate 121 and forming a cut line 125 that is to become a peripheral edge of a glass portion 124 that is to become a round hole. The former will be described below.

The above glass substrate is not limited in particular, however it is preferred to use the one produced by a float process. As a type of glass,
25 for example, an aluminosilicate glass, soda lime glass, borosilicate glass,

aluminum-magnesium alloy, or the like may be used. Particularly it is preferred to use an aluminosilicate glass since it provides a glass substrate for a magnetic disk excellent in smoothness of the main surface and strength of the substrate.

5 As an aluminosilicate glass, it is preferably made of a glass containing SiO_2 : 58-75 mass %, Al_2O_3 : 5-23 mass %, Li_2O : 3-10 mass %, Na_2O : 4-13 mass % as a main component, for example. Furthermore, preferably it is an aluminosilicate glass in which the composition of the glass is SiO_2 : 62-75 mass %, Al_2O_3 : 5-15 mass %, Li_2O : 4-10 mass %, Na_2O :
10 4-12 mass %, and ZrO_2 : 5.5-15 mass % as a main component, and the mass ratio of $\text{Na}_2\text{O}/\text{ZrO}_2$ is 0.5-2.0, and the mass ratio of $\text{Al}_2\text{O}_3/\text{ZrO}_2$ is 0.4-2.5. Furthermore, in order to eliminate a protrusion on the surfaces of the glass substrate caused by insolubles of ZrO_2 , it is preferred to use a chemically strengthened glass or the like containing SiO_2 57-74%, ZrO_2 0-2.
15 8%, Al_2O_3 3-15%, Li_2O 7-16%, and Na_2O 4-14% in mole percent.
[0026]

Then, a cut line 102 that is to become a peripheral edge of a glass portion 101 that is to become a round hole is formed on one of main surfaces of the glass substrate 100 (refer to FIG. 1(B), FIG. 2(B)). The cut
20 line 102 is formed in a perpendicular direction that is substantially perpendicular to the main surface of the glass substrate 100 (straight in a direction of the sheet thickness of the glass substrate 100). Herein, the perpendicular direction that is substantially perpendicular to the main surface of the glass substrate 100 does not have to be completely
25 perpendicular (90°) to the surface of the sheet glass substrate 100, however,

it is preferred that the angle between the main surface and the cut line 102 of the sheet glass substrate 100 is 75° or greater and 90° or smaller. However, it is particularly preferred that the angle is 90° because it allows to reduce the load in the steps of chamfering and polishing an edge face as
5 subsequent steps, while the shape of edge face can be substantially directly used as an edge face of a glass substrate for a magnetic disk.

[0027]

Herein, if a sheet glass base plate manufactured by a float process is used, it has a surface (bottom surface) that came into contact with molten
10 tin and a surface (top surface) opposite thereto. In order to form the cut line 102 that is to become a peripheral edge of the glass portion 101 that is to become the above round hole, it is preferred to choose the bottom surface to make a cut line since less chipping is generated therein.

[0028]

15 The cut line 102 can be formed by using a super hard cutter such as a glass cutter, diamond cutter, etc. The cut line 102 is made to a region halfway in the sheet glass substrate 100 from one of main surfaces.

[0029]

Then, the cut line is caused to reach the other main surface of the
20 glass substrate in a substantially perpendicular direction. The method thereof is not particularly limited and the methods include a heating method wherein the other portion excluding the glass portion that is to be separated to become the round hole is heated to around 250-400°C (T_g or smaller) by a heater such as an oven, etc., a cooling method wherein the

glass portion that is to be separated to become the round hole is cooled by a coolant such as dry ice, etc., for example.

[0030]

Then, by causing the pushing body 103 to come into contact with and
5 to apply force to the glass portion 101 that is to become a round hole in the glass substrate 100 from one of the main surfaces in the perpendicular direction, the glass portion 101 is separated from the glass substrate, thereby forming the round hole 105 in glass substrate 100 (refer to FIG. 1(C), FIG. 2(C)-FIG. 3(C)).

10 [0031]

Herein, when the glass portion 101 that is to become a round hole in the glass substrate 100 falls off, punching is performed by causing the pushing body 103 to move so that the glass 104 to fall off does not strongly collide into the edge face of the round hole 105. Specifically, the glass
15 portion is separated from the glass substrate so as not to allow the pushing body to protrude from the other main surface (FIG. 3(B)).

[0032]

More specifically, it is possible to make an amount of pushing the glass portion 101 that is to become a round hole (distance which the
20 pushing body 103 applies force to the glass portion that is to be separated in the perpendicular direction) by the pushing body smaller than the thickness of the glass substrate 100 based on a time when the pushing body 103 comes into contact with the glass portion 101 that is to become a round hole in the glass substrate 100 (refer to FIG. 2(D)).

25 [0033]

For example, when a pushing bar formed of iron, aluminum, or the like is used as the pushing body 103 to form a round hole 105 on the glass substrate 100 having a thickness L , it is possible to make an amount to push the pushing bar " t " to $0 < t < L$ (for example, $t = L/2$) after the
5 pushing bar comes into contact with the glass portion 101 that is to become a round hole in the glass substrate 100 (refer to FIG. 2(E), FIG. 3(A)).
[0034]

A distance which the pushing bar (pushing body 103) proceeds after it comes into contact with the glass portion 101 that is to become a round
10 hole in the glass substrate 100 can be controlled by using a spring or the like. For example, a bias mechanism is disposed to control movement of the pushing body, and the amount that the pushing body pushes is controlled by the bias mechanism. A case wherein the pushing body is provided with the bias mechanism so as to perform punching will be
15 described below by referencing FIG. 4.
[0035]

First, the pushing body 103 is caused to come into contact with and
to apply force to the glass portion 101 that is to become a round hole in the glass substrate 100 in which the cut line 102 is formed (refer to FIG. 4(A)).
20 The movement of the pushing body 103 is controlled by the bias mechanism 107. In FIG. 4(A), bias force is applied to the pushing body 103 by the bias mechanism 107 in a pushing direction (in a direction downward to the paper).
[0036]

After the pushing body 103 is caused to come into contact with the glass portion 101 that is to become a round hole in the glass substrate 100, bias force is applied to the pushing body 103 in a pushing direction to a certain amount of pushing (refer to FIG. 4(B)). Thereafter, when it
5 reaches a prescribed amount of pushing " t " ($0 < t < L$), the bias mechanism 107 applies bias force to the pushing body 103 in a direction opposite to the pushing direction (in a direction upward from the paper) (refer to FIG. 4(C)). This moves the pushing body 103 in a direction opposite to the pushing direction, and the glass portion 101 is moved in the pushing
10 direction by the force applied to the pushing body 103, thereby the pushing body 103 does not come into contact with the glass portion 101 (refer to FIG. 4(D)).

[0037]

As described above, by reversing the bias force applied to the
15 pushing body 103, during a period from a time when the pushing body 103 comes into contact with the glass portion 101 that is to become a round hole in the glass substrate 100 to a time when the glass portion 101 that is to become a round hole falls out, it is possible to make the force that the pushing body 103 applies to the glass portion 101 that is to become a round
20 hole zero (0) at a time when the glass portion 101 that is to become a round hole falls out. As described above, a spring or the like may be used as the bias mechanism 107.

[0038]

Furthermore, as described above, when the glass portion 101 that is
25 to become a round hole in the glass substrate is about to fall out, instead of

changing the moving direction of the pushing body 103 opposite to a direction in which the glass portion 101 that is to become a round hole falls out, it is acceptable to adjust a timing so that the glass portion 101 that is to become a round hole falls out before the pushing body 103 punches the round hole 105 (refer to FIGS. 7(A)-(D)). In this case, at a time when the glass portion 101 that is to become a round hole falls out (refer to FIG. 7(C)), the bias mechanism 107 is controlled so that the pushing body 103 does not come into contact with the glass portion 101 that is to become a round hole in the glass substrate 100.

10 [0039]

Furthermore, as a method to cause the pushing body 103 to come into contact with and to apply force to the glass portion 101 that is to become a round hole in the glass substrate 100, it is acceptable to use a method to spray a gas such as air or the like (refer to FIGS. 5(A)-(D)).

15 [0040]

When punching is performed by spraying a gas 106 such as air or the like so as to pressurize the glass substrate 100, at a time when the glass portion 101 that is to become a round hole falls out (refer to FIG. 5(C)), the gas 106 is not sprayed to the glass portion 101 that is to become a round hole in the glass substrate 100 (at a time when the glass portion is separated, the force applied by the gas 106 to the glass portion 101 that is to become a round hole is zero (0)).

[0041]

For this purpose, a period to spray the gas 106 to the glass portion 101 that is to become a round hole needs to be controlled. Specifically, it

is achieved by making a period to spray the gas 106 to the glass portion 101 that is to become a round hole shorter than a period from a time when the sprayed gas 106 hits (comes into contact with) the glass portion 101 that is to become a round hole to a time when the glass portion 101 that is to become a round hole falls out. It is acceptable to spray the gas 106 only to the glass portion 101 that is to become a round hole in the glass substrate 100, or to a wide range of the glass substrate 100 including the glass portion 101 that is to become a round hole.

[0042]

As described above, at a time when the glass portion 101 that is to become a round hole falls out, by causing the pushing body 103 to behave so that the force which the pushing body 103 applies to the glass portion 101 that is to become a round hole in the glass substrate 100 is to be zero (0), the glass portion 101 that is to become a round hole is punched straight in a perpendicular direction along the cut line 102. This prevents strong local force from being applied to the edge face of the round hole 105 when the glass portion 101 that is to become a round hole falls out, thereby generation of chipping can be suppressed at the edge face of the round hole 105.

[0043]

Furthermore, according to the present embodiment, as described above, when punching is performed by causing the pushing body 103 to come into contact with the sheet glass substrate 100, it is preferred to perform it while heating the sheet glass substrate 100. In this case, in order to heat the glass substrate 100, it is preferred to selectively heat

mainly the outside of the glass portion 101 that is to become a round hole. This creates a difference in thermal expansion between the glass portion 101 to be punched and the other portion of the glass, thereby glass portion 101 that is to become a round hole can be punched without pushing the
5 pushing body 103 more than necessary in order to perform punching.

[0044]

Below, the above method will be used to describe the manufacturing method of a glass substrate for a magnetic disk having a round hole and the manufacturing method of a magnetic disk using the glass substrate for
10 a magnetic disk in detail. The order of processes is not limited to the following description, and it can be changed accordingly.

[0045]

(1) Material processing step

In the material processing step, a glass material (1 mm of thickness)
15 produced by a float process is cut so as to form a sheet glass substrate 121 that constitutes a piece of magnetic disk (FIG. 6(A)). A glass is not particularly limited, however, an aluminosilicate glass is preferred. It is possible to use a glass containing SiO_2 : 58-75 mass %, Al_2O_3 : 5-23 mass %, Li_2O : 3-10 mass %, Na_2O : 4-13 mass % as a main component, for example.

20 In a float manufacturing method, a surface in contact with tin, which is a molten metal, is called a bottom surface, while a surface facing this bottom surface is called a top surface.

[0046]

First, the bottom surface is selected from the both surfaces of the
25 sheet float glass material prepared, and a diamond cutter is pressed to the

bottom surface so as to form a cut line 123. In the step of forming the cut line, it was decided not to cause the cut line 123 to reach the top surface that was a facing surface.

Specifically, by setting the force to push the knife of the cutter so
5 that the depth is 50% of the thickness of the sheet, the cut line is formed.
[0047]

Then, the glass material on which the cut line 123 is formed is split and bent so as to cause this cut line to move from the bottom surface to the top surface which is the facing surface to cut the glass sheet into a square
10 shape. By forming a plurality of cut lines 123, multiple square glass sheets can be produced from one sheet of glass material.

As described above, multiple glass sheets are produced from one sheet of glass material. The sheet glass produced is in a rectangle shape with a width and a length of 50 mm to 100 mm.

15 [0048]

(2) Cutting-out step

In the cutting-out step, the sheet glass substrate 121 is processed into a discal glass substrate and a round hole is formed in the center of the discal glass substrate. A specific example of the cutting-out step will be
20 described below.

[0049]

First, a diamond cutter is used on the bottom surface of the sheet glass substrate 121 to form a cut line 123 which becomes a peripheral edge at an outer periphery of a region that is to become a glass substrate for a
25 magnetic disk and a cut line 125 which becomes a peripheral edge of a

glass portion 124 that is to become a round hole (refer to FIG. 6(B)). Then, on the sheet glass substrate 121, by selectively heating a region which is located outside of the cut line 123 that is to become a peripheral edge of the discal region 122, a discal glass substrate 126 is taken out from the sheet glass substrate 121 (refer to FIG. 6(C)). Since the discal glass substrate 126 has a certain size, it can be taken out by performing the heating process.

It is preferred that the angle between the main surface and the cut line 102 of the sheet glass substrate 121 is 75° or greater and 90° or smaller, and particularly 90° is most preferred.

[0050]

Then, the discal glass substrate 126 is held horizontally and the region outside of the cut line 125 that is to become the peripheral edge of the glass portion 124 that is to become a round hole is selectively heated. Also, by causing the pushing body to come into contact with and to apply force in a perpendicular direction that is substantially perpendicular to the main surface, particularly downward in the perpendicular direction, toward the glass portion 124 that is to become a round hole in the discal glass substrate 126, the glass portion 124 that is to become a round hole in the discal glass substrate 126 is punched to form a round hole 127 (refer to FIG. 6(D)). Since the glass portion 124 that is to become a round hole is small in size, it is subjected to the heating process, and punching is performed by using the pushing body. When the glass portion 124 that is to become a round hole is punched, as described above, the glass portion is separated from the glass substrate so as not to allow the pushing body to

protrude from the other main surface. This prevents strong local force from being applied to the edge face of the round hole 127 when the glass portion 124 that is to become a round hole falls out, thereby generation of chipping can be suppressed at the edge face of the round hole 127.

5 [0051]

(3) First grinding (lapping) step

In the first lapping step, the main surface of the discal glass substrate 126 is subjected to lapping so as to trim the shape of the surface of the glass substrate and to adjust the thickness of the sheet. The first
10 lapping step can be carried out using a double-sided grinding machine employing a planetary gear mechanism with the use of alumina-based free abrasive grains. Specifically, the lapping is carried out by pressing lapping surface plates onto the both surfaces of the discal glass substrate from the upper and lower surfaces, supplying a grinding fluid containing the free
15 abrasive grains onto the main surfaces of the glass substrate, and relatively moving them to each other. By this lapping, the discal glass substrate 126 having smooth main surfaces can be obtained.

[0052]

(4) Chamfering step (chamfered surface forming step) to form chamfered
20 surfaces at outer peripheral edge face and inner peripheral edge face (round hole edge face)

In the chamfering step, chamfering is carried out on the discal glass substrate 126. Specifically, grinding is applied to the inner peripheral edge face and outer peripheral edge face using diamond grindstones,
25 thereby carrying out predetermined chamfering on the glass substrate.

According to the present embodiment, in the above cutting-out step, since the edge faces of the round hole are in substantially perpendicular direction to the main surfaces of the glass substrate, and chipping of the round hole can be reduced, it becomes possible to simplify the chamfering
5 step.

[0053]

(5) Second lapping step

In the second lapping step, the second lapping is applied to the both surfaces of the glass substrate obtained. By performing this second
10 lapping step, fine irregularities formed on the main surfaces of the glass substrate in the cutting-out step as a previous step can be removed. Consequently, it becomes possible to complete a subsequent main surface polishing step in a short time. The second lapping step can be carried out similarly to the above first lapping by using a double-sided grinding
15 machine employing a planetary gear mechanism.

[0054]

(6) Edge face polishing step

In the edge face polishing step, the outer peripheral edge face and inner peripheral edge face of the glass substrate are mirror-polished by a
20 brush polishing method. For this purpose, as polishing abrasive grains, a slurry (free abrasive grains) containing cerium oxide abrasive grains can be used. By this edge face polishing step, the edge faces of the glass substrates are finished to a mirror surface state which can prevent the segregation of sodium and potassium.

25 [0055]

(7) Main surface polishing step (first polishing step)

The first polishing step is first carried out as a main surface polishing step. This first polishing step mainly aims to remove cracks or strains remaining on the both main surfaces during the foregoing lapping
5 step. In this first polishing step, the both main surfaces are polished with a double-sided polishing machine having a planetary gear mechanism along with the use of a hard resin polisher. Cerium oxide abrasive grains may be used as a polishing agent. Furthermore, the glass substrate subjected to the first polishing step is preferably washed with a neutral
10 detergent, pure water, IPA, etc.

[0056]

As the double-sided polishing machine, a pair of abrasive clothes (abrasive pad of a hard resin polisher) can be used by attaching to the main surfaces of the upper and lower surface plates. In this double-sided
15 polishing machine, the glass substrate is placed between the abrasive clothes attached to the upper and lower surface plates, and the both main surfaces of the glass substrate can be polished by moving one or both of the upper and lower surface plates.

[0057]

20 (8) Chemical strength step

In the chemical strength step, the chemically strength treatment is applied by dipping the glass substrate in a chemically strength solution. As a chemical strength solution used for chemical strength, for example, a mixed solution of potassium nitrate (60 wt%) and sodium nitrate (40 wt%)
25 can be used. The chemical strength is performed by heating the chemical

strength solution to 300°C to 400°C and preheating the glass substrate already cleaned to 200°C to 300°C, then dipping the substrate in the chemical strength solution for three hours to four hours. It is preferable that this dipping is performed in a state that plural glass substrates are held at the edge faces in a holder so that the whole surfaces of the glass substrates are chemically strengthened.

[0058]

Lithium and sodium ions in the surface layer of the glass substrates are respectively substituted with sodium and potassium ions having relatively larger radii in the chemical strength solution by performing a dipping treatment in the chemical strength solution in this way, thereby the glass substrates are strengthened. The chemically strengthened glass substrates are washed with pure water, IPA or the like after washed with sulfuric acid.

[0059]

(9) Main surface polishing step (final polishing step)

The second polishing step is carried out as a final polishing step. The second polishing step is a step aiming to finish the both main surfaces to mirror-like surfaces. In the second polishing step, the both main surfaces are mirror-polished with a double-sided polishing machine having a planetary gear mechanism along with the use of a soft foaming resin polisher. Cerium oxide abrasive grains, colloidal silica or the like finer than the cerium oxide abrasive grains used in the first polishing step may be used as a slurry. In this final polishing step, it can be carried out

similarly to the above first polishing step by using a double-sided polishing machine employing a planetary gear mechanism.

[0060]

(10) Step for producing magnetic disks (recording layer and the like
5 forming step)

Perpendicular magnetic recording disks can be produced by film-forming, for example, an adhesion layer, a soft magnetic layer, a nonmagnetic underlayer, a perpendicular magnetic recording layer, a protective layer, and a lubricating layer sequentially on one of the main
10 surfaces of the glass substrate obtained through the foregoing steps. Cr alloys and so on can be mentioned as materials constituting the adhesion layer. CoTaZr group alloys and so on can be mentioned as materials constituting the soft magnetic layer. A granular nonmagnetic layer and so on can be mentioned as the nonmagnetic underlayer. A granular
15 magnetic layer and so on can be mentioned as the perpendicular magnetic recording layer. Hydrogenated carbons and so on can be mentioned as materials constituting a protective layer. Fluorine resins and so on can be mentioned as materials constituting the lubrication layer. For example, these recording layers and the like can be formed more specifically by film-
20 forming an adhesion layer of CrTi, a soft magnetic layer of CoTaZr/Ru/CoTaZr, a nonmagnetic granular underlayer of CoCrSiO₂, a granular magnetic layer of CoCrPt-SiO₂·TiO₂, and a hydrogenated carbon protective layer sequentially with an in-line type sputtering apparatus and then film-forming a perfluoropolyether lubricating layer by dipping method
25 on the glass substrate.

[0061]

Next, examples performed for making clear the effects of the present invention will be described.

[0062]

5 (Example 1)

(1) Material processing step

A diamond cutter was pushed onto the bottom surface of a glass base material (1 mm of thickness) produced by the float process so as to form a cut line. A rectangle-like sheet glass substrate of 70 mm x 70 mm was
 10 produced by splitting and bending it. As the glass material, aluminosilicate glass was used wherein SiO_2 : 58 wt % -75 wt % , Al_2O_3 : 5 wt % -23 wt % , Li_2O : 3 wt % -10 wt % , and Na_2O : 4 wt % -13 wt % were contained as the main components.

[0063]

15 (2) Cutting-out step

Next, the diamond cutter was used onto the bottom surface of the sheet glass substrate 121 so as to form a cut line 123 that was to become a
 peripheral edge face at an outer periphery of a region 122 that was to become a glass substrate for a magnetic disk and a cut line 125 which was
 20 to become a peripheral edge face of a region 124 that was to become a round hole (refer to FIG. 6(B)). Then, by selectively heating a region in the sheet glass substrate, that was located outside the cut line that was to become a discal peripheral edge face of the region, to 250°C with a heater a discal glass substrate 126 was taken out from the sheet glass substrate
 25 (refer to FIG. 6(C)).

Herein, the angle between the bottom surface and cut line 102 of the sheet glass substrate was set to 90°.

[0064]

Then, on the discal glass substrate 126, the region outside the cut
5 line 125 that was to become the peripheral edge face of the glass portion
124 that was to become a round hole was selectively heated to 250°C with a
heater. Also, by causing the pushing body to come into contact with and
to apply force to the glass portion 124 that was to become a round hole in
the discal glass substrate 126, the glass portion 124 that was to become a
10 round hole in the discal glass substrate 126 was punched to form a round
hole 127 (refer to FIG. 6(D)).

The region which was to become a round hole was punched by using
an iron part having a point in a conical shape as the pushing body,
wherein pressure of around 4.0 Kgf was applied to the region which was to
15 become a round hole at a time when it was contacted with. By using a
spring (UH16-20 (1 kgf/mm) by MISUMI Corp.) as the bias mechanism, at
a time when the glass portion was about to be punched from the top
surface side, the pushing body was not allowed to protrude from the other
main surface side (at a time when the glass portion was about to be
20 punched from the top surface side, the force applied by the pushing body to
the glass portion that is to become a round hole was set to zero (0)).

[0065]

(Defective inspection)

Chipping was inspected for the round hole formed on the glass
25 substrate by using an optical microscope. In the present example, round

holes were formed on 100 glass substrates. After the glasses were measured wherein chipping was generated, it was learned that chipping was generated on one of 100 substrates.

[0066]

5 (Example 2)

In the cutting-out step, instead of heating with a heater, the top surface of the glass portion that was to become a round hole was selectively cooled by a coolant at -20°C . A glass substrate for a magnetic disk was produced similarly to Example 1 by using an iron part having a point in a conical shape as the pushing body and by causing the pushing body to come into contact and to apply force in a perpendicular direction from the main surface toward a glass portion that was to be separated from the glass substrate that was to become a round hole, except that the pushing body was controlled by a computer so as not to allow it to protrude from the other main surface (lower side), thereby separating the glass portion from the glass substrate. The pressure at a time when it was caused to come into contact with the glass portion that was to become a round hole was set to around 4.0 Kgf.

[0067]

20 (Defective inspection)

Chipping was inspected for the round hole formed on the glass substrate by using an optical microscope. In the present example, round holes were formed on 100 glass substrates. After the glasses were measured wherein chipping was generated, it was learned that no chipping was generated.

[0068]

(Comparative Example)

Chipping was inspected for the glass substrate wherein everything was performed similarly to Examples except the process of forming a round hole. In Comparative Example, as illustrated in the above FIG. 8, by causing the pushing body to come into contact and to apply force as if it passed through the glass substrate, the round hole was formed by punching a region that was to become a round hole in the discal glass substrate. In Comparative Example, round holes were formed on 100 glass substrates. After the glasses were measured wherein chipping was generated, it was learned that chipping was generated on four of 100 substrates.

In both Examples and Comparative Example, the glass substrate wherein chipping was generated was subjected to subsequent steps of the lapping step, polishing step or the like and they were used as glass substrates for a magnetic disk and further to form a magnetic film or the like. It was learned that read-in and write-in errors were caused therein since a head was stable and did not float as a magnetic disk.

[0069]

The present invention is not limited to the embodiments described above and can be carried out with appropriate modification.

[0070]

Materials, size, treatment procedure, inspection procedure in the embodiments described above are examples and the invention can be carried out with various modifications within the scope in which the effects

of the present invention are exhibited. In addition, the invention can be carried out with appropriate modifications as long as they do not deviate from the scope of objects of the present invention.

[0071]

5 The present invention is based on Japanese Patent Application No. 2009-224201 filed on September 29, 2009. The contents thereof are entirely incorporated herein.

CLAIMS

1. A manufacturing method of a glass substrate for a magnetic disk comprising a step of forming a round hole in a glass substrate, the step of
5 forming a round hole comprising:

a first step of, for one of main surfaces of the glass substrate, forming a cut line that is to form a periphery of a region that is to become the round hole in a perpendicular direction that is substantially perpendicular to the main surface of the glass substrate;

10 a second step of causing the cut line to reach the other main surface of the glass substrate;

and a third step of, by causing a pushing body to come into contact and to apply force in the perpendicular direction from one of main surfaces to a glass portion that is to be separated from the glass substrate to
15 become the round hole, forming the round hole in the glass substrate by separating the glass portion;

wherein in the third step, the glass portion is separated from the glass substrate so as not to allow the pushing body to protrude from the other main surface.

20

2. The manufacturing method of a glass substrate for a magnetic disk according to claim 1, wherein a distance which the pushing body applies force to the glass portion that is to be separated in the perpendicular direction is smaller than a thickness of the glass substrate.

25

3. The manufacturing method of a glass substrate for a magnetic disk according to claim 1, wherein the distance which the pushing body applies force to the glass portion that is to be separated in the perpendicular direction is controlled by a bias mechanism to control movement of the pushing body, and the bias mechanism reverses bias force applied to the pushing body during a period from a time when the pushing body comes into contact with the glass portion that is to be separated to a time when the glass portion is separated.

4. A manufacturing method of a glass substrate for a magnetic disk comprising a step of forming a round hole in a glass substrate, the step of forming the round hole comprising:

a first step of, for one of main surfaces of the glass substrate, forming a cut line that is to form a periphery of a region that is to become the round hole in a perpendicular direction that is substantially perpendicular to the main surface of the glass substrate;

a second step of causing the cut line to reach the other main surface of the glass substrate;

and a third step of, by spraying a gas and applying force in the perpendicular direction to a glass portion that is to be separated from the glass substrate to become a round hole, forming a round hole in the glass substrate by separating the glass portion;

wherein a period to spray the gas to the glass portion that is to be separated is made shorter than a period from a time when the gas comes into contact with the region that is to become the round hole to a time

when the glass portion that is to become the round hole is separated from the glass substrate.

5. The manufacturing method of a glass substrate for a magnetic disk
5 according to any one of claims 1 to 4, wherein in the third step, a direction to separate the glass portion from the glass substrate is downward in a perpendicular direction.

6. The manufacturing method of a glass substrate for a magnetic disk
10 according to any one of claims 1 to 5, wherein the second step of causing the cut line to reach the other main surface of the glass substrate is a step of heating other portion excluding a glass portion that is to be separated from the glass substrate that is to become the round hole.

15 7. The manufacturing method of a glass substrate for a magnetic disk according to any one of claims 1 to 5, wherein the second step of causing the cut line to reach the other main surface of the glass substrate is a step of cooling the glass portion that is to be separated from the glass substrate to become the round hole.

20

8. The manufacturing method of a glass substrate for a magnetic disk according to any one of claims 1 to 7, wherein a glass substrate is produced by a float process.

9. The manufacturing method of a glass substrate for a magnetic disk according to any one of claims 1 to 8, wherein after the step of forming a round hole in a glass substrate, a step of performing chamfering processing is carried out in the glass substrate.

5

10. A manufacturing method of a magnetic disk characterized in that at least a magnetic layer is formed on a main surface of a glass substrate for a magnetic disk obtained by the manufacturing method of a glass substrate for a magnetic disk according to any one of claims 1 to 9.