MANUFACTURING METHOD OF GLASS SUBSTRATE FOR MAGNETIC DISC AND MANUFACTURING METHOD OF MAGNETIC DISC

The present disclosure relates to subject matters contained in Japanese Patent Applications No. 2006-269725 filed on September 29, 2006 and No. 2007-247315 filed on September 25, 2007, which are expressly incorporated herein by reference in their entireties.

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 disc including a chemical strengthening processing step and a cooling step and a manufacturing method of a magnetic disc.

2. Description of the Related Art

[0002] Along with advancement in information technology, information recording technology, especially magnetic recording technology, is recently making significant progress. As a substrate for a magnetic recording medium such as a hard disc drive (HDD), an aluminum substrate has been widely used. However, along with miniaturization, conversion into a thin substrate, and high-density recording of a magnetic disc, need for a glass substrate having superior flatness of the surface of the substrate and strength in comparison with the aluminum

substrate has been increasing.

[0003] Moreover, as density growth of magnetic recording technology is progressed, a magnetic head has changed from a thin film head to a magnetoresistance head (MR head) to a giant magnetic resistance head (GMR head). Along with the change in the magnetic head, float amount of the head from a substrate of the magnetic head is narrowed. A magnetic head mounting such a magnetoresistance effect element may occur thermal asperity as a unique trouble. Thermal asperity is a trouble which causes a reading error when a magneticoresistance 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 convexity or concave portion on a magnetic disc surface.

[0004] Therefore, extremely high-level of smoothness and flatness are required on the surface of a magnetic disc of a magnetic head mounting a magneticoresistance element. Moreover, if a magnetic layer is formed with dust or a foreign object attached, a convex portion is formed. Therefore, it is required for a glass substrate to prevent generation of dust by removing convexity and concave portion and also to carry out high level cleansing for completely removing a foreign object.

[0005] A glass substrate for such a magnetic disc is formed through a plurality of steps. First, a wafer is cut into a disc shape and an inner hole is made to form the shape of the glass substrate. Subsequently, edge surfaces on outer periphery and inner periphery of the cut glass substrate are chamfered and both edge surfaces are polished. Then, a main surface of the

glass substrate is also polished and finally chemical strengthening process is carried out to the polished glass substrate.

[0006] This chemical strengthening process is carried out by, for example, thermally melting molten alkaline salt and dipping a glass substrate which is a target of the process into the molten salt (chemical strengthening processing solvent) in a condition where the glass substrate is held by a glass substrate holder to cause ion exchange to occur. Here, a glass substrate holder is used for the purpose of dipping the whole surface of the glass substrate into the chemical strengthening processing solvent.

[0007] Then, finishing the chemical strengthening process of the glass substrate, the glass substrate is cooled in a condition where the glass substrate is held by the glass substrate holder. However, because temperature of the chemical strengthening process solution is around 400°C, if the glass substrate is simply cooled while being held by the glass substrate holder, the glass substrate is misshapen or warped. To solve such a problem, there is known a technique to reduce warping generated in the glass substrate by lowering freezing point of the chemical strengthening processing solvent (e.g., Patent Document 1).

[Patent Document 1] Japanese Published Unexamined Patent Application No. H2001-192239

[0008] Meanwhile to further improve recording density, a perpendicular magnetic recording method has been adopted

recently. In case of a perpendicular magnetic recording medium, compared with a case of adopting longitudinal magnetic recording method, recording density is higher and therefore roughness of a glass substrate affects more significantly. Therefore, lower roughness is required to a glass substrate.

[0009] If the glass substrate is cooled down while being held by the glass substrate holder as mentioned above, an area where cooling speed is different from other portions appears on a certain spot and this generates misshape pr warp partially. It is true that reducing a contact area between the glass substrate and the glass substrate holder improves flatness, but even in this case, low roughness, flatness, and accuracy required these days for perpendicular magnetic recording method cannot be obtained.

[0010] The reason why such an area where cooling speed differs is generated is the difference in temperature between a portion which is in contact with the glass substrate holder and other parts. Therefore, a glass substrate with a relatively large ratio of surface area, that is, with a thin thickness, more significantly shows misshape or warp.

SUMMARY OF THE INVENTION

[0011] The present invention has been made in consideration of the above problems that are in conventional cooling step of a glass substrate and is aimed at providing a new and improved manufacturing method of a glass substrate for a magnetic disc having superior low roughness and flatness which

can prevent misshape or warp from being generated in a glass substrate and a manufacturing method of a magnetic disc.

[0012] To solve the above-mentioned problems, one aspect of the present invention is a manufacturing method of a glass substrate for a magnetic disc including a cooling step for cooling a disc-shaped glass substrate caused to have heat by chemical strengthening process for exchanging ions by dipping the substrate into chemical strengthening process solution, wherein a surrounding medium of the glass substrate is cooled while the glass substrate is held by a holding unit of the glass substrate holder so that change of temperature of the glass substrate becomes uniform in a surface. The surrounding medium includes gas, liquid, and jelly solid.

[0013] According to such a configuration, it becomes possible to uniformly change temperature of the whole of the glass substrate and to prevent generation of misshape or warp.

[0014] Temperature control may be carried out by heating a noncontact portion which is a part of the glass substrate and is not in contact with the holding unit.

[0015] In the cooling step following after the chemical strengthening process, the glass substrate tends to follow surrounding temperature more than the glass substrate holder, that is, is easy to be cooled down. This is because volume (heat capacity) and surface areas differ between the glass substrate and the glass substrate holder. According to the above-mentioned configuration which heats noncontact portion of the glass substrate, that is, slows fall in temperature of

the noncontact portion, it becomes possible to substantially uniformly maintain change of temperature in the glass substrate surface.

[0016] Heating of the noncontact portion may be carried out by radiant heat from a heat sink provided opposite to the glass substrate. Moreover, the heat sink may include stainless steel with strengthened chemical resistance.

[0017] The heat sink stores thermal energy in the chemical strengthening process and releases the thermal energy in the cooling step to heat the noncontact portion. According to such a configuration, it becomes possible to heat the noncontact portion without newly providing a heat generation apparatus in the cooling step. Moreover, because heat generated in the chemical strengthening process is efficiently used, cost can be reduced.

[0018] In addition, temperature of the holding unit may be detected, temperature of the noncontact portion may be detected, heating amount may be calculated corresponding to difference in temperature between the holding unit and the noncontact portion, and the noncontact portion may be heated with the heating amount thus calculated.

[0019] By detecting temperature of the holding unit and the noncontact portion in such a manner, it becomes possible to accurately understand difference in temperature between the holding portion and the noncontact portion and to surely uniformly change temperature in the surface of the glass substrate even if temperature of the holding unit changes in

a complicated manner. Moreover, using various control theories depending on required accuracy in calculating heating amount, it becomes possible to maintain the change of temperature in the surface of the glass substrate more accurately and uniformly.

[0020] In addition to the above-mentioned configuration to heat the noncontact portion or independently therefore, the holding unit may be cooled more so that change of temperature in the surface of the glass substrate becomes uniform. Thus, it is possible to prevent generation of misshape or warp of the glass substrate.

[0021] Temperature of the noncontact portion which is a part of the glass substrate and is not in contact with the holding unit may be detected, temperature of the holding unit may be detected, cooling amount may be calculated corresponding to difference in temperature between the holding unit and the noncontact portion, and the noncontact portion may be cooled with the cooling amount thus calculated.

[0022] Moreover, the holding unit may have material and/or shape which allows change of temperature becomes similar to that of the glass substrate.

[0023] According to such a configuration, change or temperature of the holding unit of the glass substrate and the change of temperature of the glass substrate become equal and cooling speed of the whole of the glass substrate becomes uniform. Therefore, irrespective of the scale of contact area, it becomes possible to prevent misshape or warp from generating

in the glass substrate.

[0024] Front surface side and rear surface side of an outer periphery of the glass substrate may be uniformly attached to the holding unit.

[0025] Misshape or warp generated on a glass substrate is also caused by difference in change of temperature between front surface side and rear surface side of the outer periphery edge surface. By allowing the front surface side and rear surface side of the outer periphery edge surface to be attached to the holding unit uniformly, it becomes possible to match the cooling temperature of the front surface side and rear surface side and to prevent generation of misshape or warp of the glass substrate.

[0026] To solve the above-mentioned problems, according to another aspect of the present invention, there is provided a manufacturing method of a glass substrate including a cooling step for cooling a disc-shaped glass substrate caused to have hear by chemical strengthening process for carrying out ion exchange by dipping the glass substrate into chemical strengthening processing solvent wherein the glass substrate is cooled while being held by a holding unit of a glass substrate holder for storing a glass substrate so that change of temperature of the glass substrate becomes uniform in the surface thereof.

[0027] In the present invention, a glass substrate is cooled while temperature is controlled so that change of temperature of the glass substrate becomes uniform in the

surface thereof. According to such a configuration, change of temperature of the whole of the glass substrate is enabled and it becomes possible to prevent generation of misshape or warp of the glass substrate.

[0028] The glass substrate may be cooled while the noncontact portion which is a part of the glass substrate and is not in contact with the holding unit is heated so that change of temperature of the glass substrate becomes uniform in the surface.

[0029] Here, temperature of the noncontact portion and the holding unit are detected, thermal amount is calculated in response to the difference in temperature between the noncontact portion and the holding unit, and the glass substrate is cooled while the noncontact portion is heated with the heat amount thus calculated.

[0030] After the chemical strengthening process is carried out for the glass substrate in a condition where the glass substrate is held by the glass substrate holder, the glass substrate holder may be cooled while holding the heated glass substrate.

[0031] By such a configuration, it becomes possible to proceed to the cooling step while the glass substrate is being held. Therefore, the heated glass substrate does not need to be moved and the cooling step can be carried out smoothly.

[0032] Moreover, at least a magnetic layer is formed on a glass substrate for a magnetic disc manufactured by the above-mentioned manufacturing method of a glass substrate for

a magnetic disc. A manufacturing method of a magnetic disc will also be provided.

[0033] According to the present invention as explained above, it becomes possible to uniformly maintain cooling speed of the whole of a glass substrate, to prevent generation of misshape or warp, and to maintain superior flatness.

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 illustrating a cause of misshape or warp.

[FIG. 2] A vertical cross-sectional view taken along AA' line in FIG. 1 for explanation of contact condition of a holding unit provided to hold a bottom surface of a glass substrate.

[FIG. 3] A horizontal cross-sectional view taken along BB' line in FIG. 1 for explanation of contact condition of a holding unit provided to hold a side surface of a glass substrate.

[FIG. 4] A vertical cross-sectional view for explaining that a glass substrate is warped due to difference in change of temperature.

[FIG. 5] A perspective view showing a configuration of a glass substrate holder.

[FIG. 6] A view for explaining change in transition of temperature of a glass substrate by a substrate heating unit.

[FIG. 7] A view for explaining change in transition of temperature of a glass substrate by a holder cooling unit.

[FIG. 8] A horizontal cross-sectional view for explaining location of a heat sink.

[FIG. 9] A horizontal cross-sectional view for explaining another location of the heat sink.

[FIG. 10] A perspective view for showing another configuration of a glass substrate holder.

[FIG. 11] A block diagram for explaining closed loop control using a substrate heating unit.

[FIG. 12] A block diagram for explaining closed loop control using a holder cooling unit.

[FIG. 13] A perspective view showing another configuration of a glass substrate.

[FIG. 14] A view for explaining change in transition of temperature of a glass substrate by a substrate heating unit.

[FIG. 15] A view for explaining change in transition of temperature of a glass substrate by a holder cooling unit.

[FIG. 16] A block diagram for explaining closed loop control using a substrate heating unit.

[FIG. 17] A block diagram for explaining closed loop control using a holder cooling unit.

The Best Mode for Carrying Out the Claimed Invention

[0034] Hereinafter, preferred embodiments of the present invention will be explained in detail with reference to attached

figures. Here, in the present application and attached figures, same reference numerals will be denoted to an element having substantially same function and redundant explanation thereof will be omitted.

[0035]

(First embodiment: Cooling step of glass substrate)

A glass substrate for a magnetic disc is formed through a plurality of steps. In the final stage thereof, the glass substrate is dipped into chemical strengthening processing solvent of alkali salt (e.g., molten salt) to carry out chemical strengthening process to exchange ions. Moreover, following the chemical strengthening process, a cooling step for cooling the glass substrate heated by the chemical strengthening process is carried out. The glass substrate is held by a glass substrate holder during the chemical strengthening process and the cooling step.

[0036] There are a plurality of glass substrates held by the glass substrate holder which is lifted from the chemical strengthening processing solvent after the chemical strengthening process is finished. On such a glass substrate, a thin film of the molten liquid is flecked. Especially, at a contact portion of the glass substrate and a holding unit of the glass substrate holder, much molten liquid remains due to surface tension. Therefore, if the molten liquid is coagulated in the cooling step, there occurs difference in thermal expansion between the holding unit of the glass substrate and other parts (noncontact portion). Then, because the expanded

condition is maintained at the contacting portion with the holding unit and this portion is condensed later than other portions, there occurs misshape or warp.

[0037] FIG. 1 is a view for explaining a cause of misshape or warp. Here, in a slot formed by a plurality of holding units 110 of a glass substrate 100, a glass substrate 10 is held. Misshape or warp is caused by temperature distribution in the surface of the glass substrate and the temperature distribution is generated by the difference in change of temperature between the glass substrate 10 and the holding unit 110. The difference in change of temperature is generated by the difference in amount of thermal release to a surrounding medium between cubic volume of the chassis (thermal capacity) and surface area and therefore the glass substrate having a large surface area for the cubic volume thereof is more easily cooled than the glass substrate holder which has predetermined strength of a chassis and therefore inevitably has large cubic volume. Thus, there occurs difference in change of temperature between the glass substrate and the holding unit.

[0038] If there occurs difference in change of temperature as mentioned above, then, thermal energy transfer occurs from the glass substrate holder 100 to the glass substrate 10 through the holding unit 110. Therefore, at a contact point 112 of the glass substrate 10 with the holding unit 110, thermal energy works to prevent cooling and temperature is lowered later at contact portions 114 which are in the vicinity of a contact point with the glass substrate 10 than a noncontact portion 116 which

is the remaining part of the glass substrate 10. Hence, temperature distribution or transition of change of temperature in a surface of the glass substrate 10 becomes non-uniform.

[0039] FIG. 2 is a vertical cross-sectional view taken along AA' line in FIG. 1 for explanation of contact condition of a holding unit provided to hold a bottom surface of a glass substrate. The glass substrate 10 is put on the holding unit 110 and is not fixed. Therefore, there is idle space in a direction orthogonal to the main surface of the glass substrate in the holding unit 110. However, in the holding unit 110 having a V-shaped groove according to the present embodiment, the glass substrate 10 is in contact with the holding unit 110 at the bottom surface and two points 112 and chemical strengthening processing solvent 118 is filled in the vicinity thereof. Therefore, in the holding unit 110 provided on the bottom surface of the glass substrate 10, contact area with the glass substrate 10 becomes large and transition of thermal energy in the cooling step is increased due to the large contact area. Such a difference in change of temperature in the surface of the glass substrate 10 causes misshape or warp.

[0040] FIG. 3 is a horizontal cross-sectional view taken along BB' line in FIG. 1 for explanation of contact condition of a holding unit provided to hold a side surface of a glass substrate. In this case, because the glass substrate 10 is also not fixed to the holding unit 110 and therefore is inclined to one side of the holding unit 110 to be in contact therewith. Therefore, the contact point 112 is provided only one point on

one surface. In the holding unit 110 where glass substrates are provided on side surfaces, the chemical strengthening processing solvent 118 does not remain due to the gravity and only a small amount of the chemical strengthening processing solvent 118 remains due to surface tension, as shown in FIG. 3.

[0041] In this case, since contact area with the holding unit 110 is small and the remaining amount of the chemical strengthening processing solvent 118 is small, it is assumed that misshape or warp of the glass substrate is reduced. However, misshape or warp occurs even when change of temperature differs between front and rear surfaces of the glass substrate 10. This is because the same phenomenon as the warp due to difference in thermal expansion between the contact portion with the holding unit 110 and other portion occurs between front and rear surfaces of an outer periphery edge surface of the glass substrate 10.

[0042] FIG .4 is a vertical cross-sectional view for explaining that a glass substrate is warped due to difference in change of temperature. The glass substrate 10 includes a surface 120 and a surface 122 and in FIG. 4, the surface 122 side of outer periphery edge surface of the glass substrate 10 is in contact with the holding unit 110. Therefore, cooling speed in the surface 122 side is slower than the surface 120 side and a thermally expanded condition is maintained. Therefore, as shown in FIG. 4, only the surface 122 side is stretched to radius direction of the substrate, causing warp

having concave shape in the direction of the surface 120 side. Measuring the undulation by the warp using an optical flat for measuring interference fringe, the value reached 8 nm. Therefore, it is understood that to prevent misshape or warp, similarly to the difference in change of temperature between the glass substrate 10 and the holding unit 110, difference in change of temperature between front and rear surfaces of the glass substrate 10 must be taken into consideration.

[0043] The inventors of the present invention focused their attention on the fact that the cause of misshape or warp is difference in change of temperature (cooling speed) in a surface of a glass substrate and found out that the problem of misshape can be solved by reducing difference in change of temperature to accomplish the present invention.

[0044] To reduce the difference in change of temperature in a surface of a glass substrate, four means for solving the problems will be used in the present embodiments. The means are: (1) to prevent generation of difference in change of temperature in the surface of a glass substrate by matching the change of temperature of either a noncontact portion 116 or the glass substrate 10 or the holding unit 110 to another; (2) to equalize change of temperature of the glass substrate 10 and the holding unit 110 by equalizing thermal capacity of the both; (3) to cause both the front and rear surfaces of the outer periphery edge surface of the glass substrate 10 to be uniformly in contact with the holding unit 110 to prevent difference in change of temperature between front and rear surfaces; and (4)

to limit contact area with the holding unit 110 as small as possible so that flow of thermal energy from the holding unit 110 into the contact area is reduced. Hereinafter, such methods for solving the problems will be described.

[0045]

(Glass substrate holder 100)

FIG. 5 is a perspective view showing a configuration of a glass substrate holder. The glass substrate holder 100 includes the holding unit 110, a substrate heating unit 150, a holder cooling unit 160, and a fixing unit 170 and holds the glass substrate 10 during the cooling step.

[0046] In the present embodiment, the cooling step of the glass substrate 10 following after the chemical strengthening process will be explained. Here, the glass substrate holder 100 may also be used in the chemical strengthening process or may be used solely in the cooling step. In other words, the glass substrate 10 may be stored in the glass substrate holder 100, chemically strengthened, and maintaining the condition where the glass substrate 10 is stored, the cooling step may be subsequently carried out. Otherwise, following the chemical strengthening process, the heated glass substrate 10 may be moved into the glass substrate holder 100 to carry out the cooling step.

[0047] Thus, by carrying out chemical strengthening process of the glass substrate 10 in a condition where the glass substrate 10 is held in the glass substrate holder 100 and subsequently cool the heated glass substrate 10 in a condition

where the glass substrate 10 is held in the glass substrate holder 100, it becomes possible to carry out cooling of a heated glass substrate 10 without unnecessarily moving it. Moreover, because stress by putting the glass substrate 10 in and out from the glass substrate holder 10, it is difficult for the glass substrate 10 to generate misshape or warp.

[0048] The holding unit 110 is formed by curving a thin plate and a plurality of projection are formed in a wave-like manner on an expanded outer surface thereof to hold the glass substrate 10 in a V-shaped groove formed between the projection on the surface of the expanded outer surface. The configuration to curve a thin plate may be substituted by a configuration of causing a thin plate to form projection having certain angle. Moreover, a V-shaped return point of the V-shaped groove may be rounded.

[0049] By forming the groove of the holding unit 110 for holding a glass substrate to have the V-shape, even if the glass substrate is inclined to a direction orthogonal to the groove, there are two contact points in the bottom surface. By limiting contact area to minimum with such a configuration, it becomes possible to reduce thermal transition between the glass substrate 10 and the holding unit 110.

[0050] The substrate heating unit 150 includes a heat source such as a heater and directly or indirectly heats the noncontact portion 116 of the glass substrate 10 while the glass substrate holder 100 and the glass substrate 10 are cooled via a surrounding medium. Such a substrate heating unit 150 may

include an electric heater which can control heating value in response to an external signal. According to the configuration to heat the noncontact portion 116 of the glass substrate 10 to slow cooling speed of the noncontact portion 116, it becomes possible to maintain change of temperature in the surface of the glass substrate 10 substantially uniform.

[0051] According to FIG. 5, the substrate heating unit 150 is formed to have a disc-shape similarly to the glass substrate 10 and is provided opposite to the glass substrate 10. The purpose of the substrate heating unit 150 in the present embodiment is to prevent the glass substrate 10 from being cooled earlier than the holding unit 110, that is, to heat only the noncontact portion 116 of the glass substrate 10. For example, it is expected that the effect of heating is decreased if the substrate heating unit 150 heats contact portion 114 of the holding unit 110 or the holding unit 110 as well as the noncontact portion 116 of the glass substrate 10. Therefore, in the present embodiment, the substrate heating unit 150 is formed to have a disc-shape similarly to the glass substrate 10 so that only the noncontact portion 116 of the glass substrate 10 is heated without fail.

[0052] FIG. 6 is a view for explaining change in transition of temperature of the glass substrate 10 by the substrate heating unit 150. In FIG. 6, horizontal axis shows time and vertical axis shows temperature and transition of temperature 210 of the noncontact portion 116 of the glass substrate 10 and transition of temperature 212 of the contact portion 114 are

shown. According to FIG. 6, during the chemical strengthening process, the noncontact portion 116 and the contact portion 114 of the glass substrate 10 have similar temperatures and are stable. However, when the cooling step is started, each temperature undergoes a transition with different temperature change amount. Therefore, the substrate heating unit 150 slows cooling speed of the noncontact portion 116 and controls the transition of temperature 210 of the noncontact portion 116 so that the transition of temperature 210 of the noncontact portion 116 follows the transition of temperature 212 of the contact portion 114, as shown by an arrow.

[0053] The holder cooling unit 160 includes a cooling device using a compressor or chlorofluorocarbon, or a thermal release device such as a cooling fan, a cooling fin, or peltier element and further cools the holder unit 110 or the glass substrate holder 100 while the glass substrate holder 100 and the glass substrate 10 are cooled via a surrounding medium. The holder cooling unit 160 may include a device which can control cooling amount in response to an external signal. According to the configuration to cool the holder unit 110 to enhance reduction in cooling speed of the holder unit 110, it becomes possible to maintain change of temperature in the surface of the glass substrate 10 to be substantially uniform.

[0054] FIG. 7 is a view for explaining change in transition of temperature of the glass substrate 10 by the holder cooling unit 160. Similarly to FIG. 6, horizontal axis shows time and vertical axis shows temperature in FIG. 7 and transition of

temperature 210 of the noncontact portion 116 of the glass substrate 10 and transition of temperature 212 of the contact portion 114 are shown. When the cooling step is started, each temperature undergoes a transition with different temperature change amount. However, using the holder cooling unit 160, cooling speed of the contact portion 114 is accelerated and the transition of temperature 210 of the noncontact portion 116 is controlled so that the transition of temperature 210 of the noncontact portion 116 follows the transition of temperature 212 of the contact portion 114, as shown by an arrow.

[0055] Either of the above-mentioned substrate heating unit 150 or the holder cooling unit 160 may be provided, or both may be provided.

[0056] The fixing unit 170 includes two holder fixing units 172 for fixing the holder unit 110 and four reinforcing plates 174 connected to the holder fixing units 172 to strengthen the holder fixing units 172.

[0057] By use of the glass substrate holder 100 explained above, in the manufacturing method of a glass substrate for a magnetic disc according to the present embodiment, a surrounding medium of the glass substrate holder 100 is cooled and temperature is controlled in a condition where the glass substrate 10 is held by the holding unit 110 of the glass substrate holder 100 so that change of temperature of the glass substrate 10 becomes uniform in the surface thereof.

[0058] According to such a configuration, it becomes possible to uniformize the cooling speed of the whole of the

glass substrate 10 and to prevent generation of misshape or warp of the glass substrate irrespective of the size of contact area. Therefore, it becomes possible to generate a glass substrate for a magnetic disc having superior flatness, boost yield, and obtain stable and high productivity.

[0059]

(Heat sink 152)

Moreover, the above-mentioned substrate heating unit 150 may include a heat sink 152 provided opposite to the glass substrate 10. The heat sink 152 is stainless steel or the like based on steel or steel use stainless (SUS) having strengthened chemical resistance and has a disc-shape similarly to the glass substrate 10.

[0060] FIG. 8 is a horizontal cross-sectional view for explaining location of the heat sink 152. According to FIG. 8, a plurality of glass substrates 10 are stored in the glass substrate holder 100 and between two glass substrates 10 adjacent to each other, the heat sink 152 is provided. The heat sink 152 is formed to have a disc-shape smaller than the glass substrate 10, stores thermal energy in the chemical strengthening process which is a preceding process to the cooling step, and releases the thermal energy thus stored in the cooling step. The released thermal energy heats the noncontact portion 116 of the opposing glass substrate 10.

[0061] According to such a configuration, it becomes possible to heat the noncontact portion 116 of the glass substrate 10 without newly providing a heating device in the

cooling step. Moreover, since heat in the chemical strengthening process is efficiently used, cost can be reduced. Further, since the heat sink 152 is provided in an idle space, number of glass substrates to be chemically strengthened does not need to be reduced.

[0062] FIG. 9 is a horizontal cross-sectional view for explaining another location of the heat sink 152. In FIG. 8, the heat sink 152 was provided in advance between slots where the glass substrate 10 is located. However, in FIG. 9, the heat sink 152 is provided alternately with the glass substrate 10 in a detachable manner in a slot where the glass substrate 10 is located. Therefore, although the number of glass substrates 10 stored in the glass substrate holder 100 is reduced, it becomes possible to provide the heat sink 152 in an existing glass substrate holder. Therefore, it becomes possible to obtain effect of the present embodiment with cheap and easy configuration.

[0063] Here, a comparison experiment was conducted to compare a case where the glass substrates 10 are inserted in all the slots of the glass substrate holder 100 and a case where the glass substrates 10 and the heat sinks 152 are alternately inserted. While misshape and warp were confirmed in the former, they were not confirmed in the latter. Moreover, magnetic discs were manufactured by attaching a magnetic film on the generated glass substrates and grind height test was conducted. A magnetic disc manufactured with glass substrate of the former crushed at float amount of 8 nm, while a magnetic disc

manufactured with glass substrate of the latter did not cause any troubles.

[0064]

(Holding unit temperature detection unit 310, substrate temperature detecting unit 320)

The substrate heating unit 150 of the heat sink 152 or the like having such a configuration carries out open loop control that expects temperature transition of the holding unit 110 and changes temperature of the noncontact portion 116 of the glass substrate 10 by the same degree as expected temperature transition of the holding unit 110. Hereinafter, closed loop control is applied to the follow-up control of temperature to enable more superior flatness.

[0065] FIG. 10 is a perspective view for showing another configuration of a glass substrate holder. The glass substrate holder 300 having such a configuration includes the holding unit 110, the substrate heating unit 150, the holder cooling unit 160, the fixing unit 170, a holding unit temperature detection unit 310, and a substrate temperature detection unit 320.

[0066] Because the holding unit 110 and the fixing unit 170 mentioned here as components have substantially same function as the previous ones and therefore redundant explanation thereof is omitted. Here, only the substrate heating unit 150, the holder cooling unit 160, the holding unit temperature detection unit 310, and the substrate temperature detection unit 320 will be mainly explained.

[0067] The holding unit temperature detection unit 310

includes a temperature gauge which can measure temperature of a contact area and detects temperature of the holding unit 110 in a condition where the holding unit temperature detection unit 310 is in contact with the holding unit 110.

[0068] The substrate temperature detection unit 320 includes an infrared ray detecting temperature sensor which can measure the surface temperature in a contactless manner and detects the temperature of the glass substrate 10. Moreover, similarly to the holding unit temperature detection unit 310, the substrate temperature detection unit 320 may include a temperature gauge which can measure temperature of a contact area.

[0069] Using such holding unit temperature detection unit 310 or the substrate temperature detection nunit 320, temperature of the holding unit 110 and the noncontact portion 116 of the glass substrate 10 is detected and either is set as a target value while the other is set as a feedback value to carry out closed loop control.

[0070] FIG. 11 is a block diagram for explaining closed loop control using the substrate heating unit 150. According to the FIG. 11, the holding unit temperature detection unit 210 detects the temperature of the holding unit 110 and the substrate temperature detection unit 320 detects the temperature of the noncontact portion 116 of the glass substrate 10, calculates heating amount by multiplying proportional constant or other control parameter to a value acquired by subtracting temperature of the noncontact portion 116 of the

glass substrate 10 from the temperature of the holding unit 110, and transmits the heating amount thus acquired to the substrate heating unit 150. The substrate heating unit 150 heats the noncontact portion 116 of the glass substrate 10 corresponding to the inputted heating amount.

[0071] According to such closed loop control, it is possible to accurately understand difference in temperature between the noncontact portion 116 of the glass substrate 10 and the holding portion 110 and even if the temperature of the holding unit 110 changes in a complicated manner, it is possible to cause the temperature of the noncontact portion 116 of the glass substrate 10 to follow the temperature of the holding unit 110 without fail and to uniformize the change of temperature in the surface of the glass substrate 10.

[0072] FIG. 12 is a block diagram for explaining closed loop control using the holder cooling unit 160. According to FIG. 12, the substrate temperature detection unit 320 detects the temperature of the noncontact portion 116 of the glass substrate 10 and the holding unit temperature detection unit 310 detects the temperature of the holding unit 110, calculates cooling amount by multiplying proportional constant or other control parameter to a value acquired by subtracting the temperature of the holding unit 110 from temperature of the noncontact portion 116 of the glass substrate 10, and transmits the cooling amount thus acquired to the holder cooling unit 160. The holder cooling unit 160 cools the holding unit 110 corresponding to the inputted cooling amount.

[0073] According to such a closed loop control, it is possible to accurately understand difference in temperature between the noncontact portion 116 of the glass substrate 10 and the holding portion 110 and even if the temperature of the holding unit 110 changes in a complicated manner, it is possible to cause the temperature of the holding unit 110 to follow the temperature of the noncontact portion 116 of the glass substrate 10 without fail and to uniformize the change of temperature in the surface of the glass substrate 10.

[0074] Moreover, using various control theories corresponding to required accuracy in calculation of the above-mentioned heating amount or cooling amount, it becomes possible to maintain change of temperature in the surface of the glass substrate 10 uniformly with more accuracy.

[0075]

(Other modification method)

Other than controlling change of temperature between the noncontact portion 116 of the glass substrate 10 or the holding unit 110, there is a method to reduce difference in change of temperature. In addition to the above-mentioned methods of controlling the change of temperature, following configuration enables to generate a glass substrate for a magnetic disc having more superior flatness.

[0076] First, the holding unit 110 includes the material having same thermal capacity as the glass substrate 10 and is formed to have an equal ratio of cubic content and surface area as that of the glass substrate 10.

[0077] According to such a configuration, change of temperature of the holding unit 110 of the glass substrate holder 300 and the glass substrate 10 are equalized and cooling speed of the whole of the glass substrate 10 is uniformized. Therefore, irrespective of the scale of the contact area, it is possible to prevent generation of misshape or warp.

[0078] Moreover, the front surface side and the rear surface side of the outer periphery edge surface of the glass substrate 10 is caused to be uniformly in contact with the holding unit 110.

[0079] As mentioned above, misshape or warp generated in the glass substrate 10 is also caused by difference in change of temperature between the front surface side and the rear surface side of the outer periphery edge surface. The front surface side and the rear surface side of the outer periphery edge surface are caused to be in contact with the holding unit 110 and it is enabled to match the cooling speed on the front surface side and the rear surface side and to prevent generation of misshape or warp in the glass substrate 10.

[0080] Moreover, the glass substrate holder 300 may be inserted into a constant temperature oven and cooling speed may be lowered than usual to prevent generation of difference in change of temperature so that amount of thermal transition is within a predetermined range. Similarly, it is also possible to cause temperature modulated liquid run in circles in the glass substrate holder 300 to take more cooling time.

[0081]

(Second embodiment: Chemical strengthening process of glass substrate 10)

Further, not only in the above-mentioned cooling step, but also in the chemical strengthening process which is a preceding step, difference in heating speed between a portion in contact with the glass substrate holder and other portion which is not in contact is generated and misshape or warp is generated partially. Such misshape or warp may become a minute convex or concave portion on a magnetic disc and cause the above-mentioned thermal asperity.

[0082] The configuration to raise flatness of the glass substrate 10 by matching the change of temperature in the surface of the glass substrate 10 described in the above-mentioned first embodiment can be applied not only to the cooling step following the chemical strengthening process but also to the chemical strengthening process. Hereinafter, as a second embodiment, characteristics in the chemical strengthening process will be described.

[0083] FIG. 13 is a perspective view showing another configuration of a glass substrate holder 400. The glass substrate holder 400 includes a holding unit 110, a substrate cooling unit 410, a holder heating unit 420, a fixing unit 170, a holding unit temperature detection unit 310, and a substrate temperature detection unit 320.

[0084] Because the holding unit 110, the fixing unit 170, the holding unit temperature detection unit 310, and the substrate temperature detection unit 320 already mentioned as

components have substantially same function as the above and therefore, redundant explanation thereof is omitted. Here, the substrate cooling unit 410 and the holder heating unit 420 having different configuration are mainly explained.

[0085] The substrate cooling unit 410 includes a heat releasing device such as a cooling fan and cools the noncontact portion 116 of the glass substrate 10 while the glass substrate holder 400 and the glass substrate 10 are heated via a surrounding medium (in this case, chemical strengthening processing solvent). Such substrate cooling unit 410 may include a device which can control cooling amount in response to an external signal. According to the configuration thus cooling the noncontact portion 116 to suppress raise of temperature of the noncontact portion 116, it is possible to maintain the change of temperature in the surface of the glass substrate 10 substantially uniform.

[0086] According to FIG. 13, the substrate cooling unit 410 is formed to have a disc-shape similarly to the glass substrate 10 and is provided opposite to the glass substrate 10. The aim of the substrate cooling unit 410 in the present embodiment is to prevent the noncontact portion 116 of the glass substrate 10 from being heated earlier than the holding unit 110, similarly to the cooling step. In other words, it is aimed at cooling only the noncontact portion 116 of the glass substrate 10. Therefore, in the present embodiment, the substrate cooling unit 410 is formed to have a disc-shape similarly to the glass substrate 10 and only the noncontact

portion 116 of the glass substrate 10 is cooled without fail.

[0087] FIG. 14 is a view for explaining change in transition of temperature of the glass substrate 10 by the substrate cooling unit 410. In FIG. 14, horizontal axis shows time and vertical axis shows temperature and transition of temperature 210 of the glass substrate 10 and transition of temperature 212 of the contact portion 114 are shown. According to FIG, 14, before start of the chemical strengthening process, the noncontact portion 116 and the contact portion 114 of the glass substrate 10 have same temperature and are stable. However, when the chemical strengthening process is started, each temperature undergoes a transition with different temperature change amount. Therefore, the substrate cooling unit 410 slows heating speed of the noncontact portion 116 of the glass substrate 10 and the transition of temperature 210 of the noncontact portion 116 is controlled so that the transition of temperature 210 of the noncontact portion 116 follows the transition of temperature 212 of the contact portion 114, as shown by an arrow.

[0088] The holder heating unit 420 includes a heat source such as a heater and further heats the holding unit 110 or the glass substrate holder 400 while the glass substrate holder 400 and the glass substrate 10 are heated via the chemical strengthening processing solvent. Such holder heating unit 420 may include a device which can control heating amount in response to an external signal. According to the configuration that heats the holding unit 110 in such a manner to enhance

increase in temperature of the holding unit 110, it becomes possible to maintain the change of temperature in the surface of the glass substrate 10 substantially uniform.

[0089] FIG. 15 is a view for explaining change in transition of temperature of the glass substrate 10 by the holder cooling unit 420. In FIG. 15, in the same manner as in FIG. 14, horizontal axis shows time and vertical axis shows temperature and transition of temperature 210 of the glass substrate 10 and transition of temperature 212 of the contact portion 114 are shown. Once the chemical strengthening process is started here, each temperature undergoes a transition with different temperature change amount. However, using the holder heating unit 420, heating speed of the contact portion 114 is accelerated and the transition of temperature 210 of the noncontact portion 116 is controlled so that the transition of temperature 210 of the noncontact portion 116 follows the transition of temperature 212 of the contact portion 114, as shown by an arrow.

[0090] Either of the above mentioned substrate cooling unit 410 and the holder heating unit 420 may be provided, or both may be provided.

[0091]

(Holding unit temperature detection unit 310, substrate temperature detection unit 320)

Moreover, similarly to the cooling step, the holding unit temperature detection unit 310 or the substrate temperature detection unit 320 may be applied for follow-up control of

temperature to detect temperature of the holding unit 110 and the noncontact portion 116 of the glass substrate 10 so that closed loop control can be carried out setting either of the temperatures as a target value and the other as a feedback value.

[0092] FIG. 16 is a block diagram for explaining closed loop control using the substrate cooling unit 410. According to FIG. 16, the holding unit temperature detection unit 310 detects temperature of the holding unit 110 and the substrate temperature detection unit 320 detects temperature of the noncontact portion 116 of the glass substrate 10, calculates cooling amount by multiplying proportional constant or other control parameter to a value acquired by subtracting temperature of the noncontact portion 116 of the glass substrate 10 from the temperature of the holding unit 110, and transmits the cooling amount thus acquired to the substrate cooling unit 410. The substrate cooling unit 410 cools the noncontact portion 116 of the glass substrate 10 corresponding to the inputted cooling amount.

[0093] According to such closed loop control, it is possible to accurately understand difference in temperature between the noncontact portion 116 of the glass substrate 10 and the holding portion 110 and even if the temperature of the holding unit 110 changes in a complicated manner, it is possible to uniformize the change of temperature in the surface of the glass substrate 10 without fail.

[0094] FIG. 17 is a block diagram for explaining closed loop control using the holder heating unit 420. According to

FIG. 17, the substrate temperature detection unit 320 detects the temperature of the noncontact portion 116 of the glass substrate 10, the holding unit temperature detection unit 310 detects the temperature of the holding unit 110, calculates heating amount by multiplying proportional constant or other control parameter to a value acquired by subtracting the temperature of the holding unit 110 from temperature of the noncontact portion 116 of the glass substrate 10, and transmits the heating amount thus acquired to the holder heating unit 420. The holder heating unit 420 heats the holding unit 110 in response to the inputted heating amount.

[0095] According to such closed loop control, it is possible to accurately understand difference in temperature between the noncontact portion 116 of the glass substrate 10 and the holding portion 110 and even if the temperature of the holding unit 110 changes in a complicated manner, it is possible to uniformize the change of temperature in the surface of the glass substrate 10 without fail.

[0096] Moreover, using various control theories in response to required accuracy in calculation of the above-mentioned heating amount or cooling amount, it becomes possible to maintain identity between temperature the glass substrate 10 and the holding unit 110 with more accuracy.

[0097] As explained above, the second embodiment provides a manufacturing method of a glass substrate for a magnetic disc including a chemical strengthening processing step to dip a disc-shaped glass substrate into chemical strengthening

processing solvent wherein the substrate is dipped in the chemical strengthening processing solvent in a condition where the substrate is held by a holding unit of a glass substrate holder for storing the glass substrate to control temperature so that temperature of the glass substrate becomes uniform in the surface thereof.

[0098] Moreover, temperature control may be carried out by cooling a noncontact portion which is a part of a glass substrate and not in contact with a holding unit. Further, temperature of the holding unit may be detected, temperature of the noncontact portion may be detected, cooling amount may be calculated on depending on the difference in temperature of the holding unit and the noncontact portion and the noncontact portion may be cooled with the cooling amount thus calculated.

[0099] On the contrary, temperature control may be carried out by further heating the holding unit. Temperature of the holding unit may be detected, temperature of the noncontact portion may be detected, heating amount may be calculated on depending on the difference in temperature of the holding unit and the noncontact portion and the holding unit may be heated with the heating amount thus calculated.

[0100] According to such a configuration, not only in the cooling step but also in the chemical strengthening process, change of temperature of the holding unit 110 of the glass substrate 400 and the noncontact portion 116 of the glass substrate 10 can be matched and heating speed of the whole of the glass substrate 10 can be uniformized. Therefore, it is

possible to prevent generation of misshape or warp, irrespective of scale of the contact area.

[0101] Moreover, the manufacturing method of a glass substrate for a magnetic disc according to the present embodiment may be a manufacturing method of a glass substrate for a magnetic disc including a cooling step for cooling a disc-shaped glass substrate 10 which was heated by chemical strengthening process for carrying out ion exchange by dipping the substrate into chemical strengthening processing solvent, wherein the glass substrate 10 is cooled so that change of temperature of the glass substrate 10 becomes uniform in the surface thereof while the glass substrate 10 is held by the holding unit 110 of the glass substrate holder 100 for storing the glass substrate 10.

[0102] According to such a configuration, while temperature of the substrate is controlled so that change of temperature in the surface of the glass substrate 10 becomes uniform in the surface thereof, the glass substrate 10 is cooled. Thus, it becomes possible to uniformize change of temperature of whole of the glass substrate and to prevent generation of misshape or warp.

[0103] Moreover, the glass substrate 10 may be cooled while the noncontact portion 116 of the glass substrate 10 which is not in contact with the holding unit 110 so that change of temperature of the glass substrate 10 becomes uniform.

[0104] Here, the glass substrate is cooled while temperature of the noncontact portion 116 and temperature of

the holding unit 110 are detected, heating amount is calculated depending on the difference in temperature of the noncontact portion 116 and the holding unit 110, and the noncontact portion 116 is heated with the heating amount thus calculated.

[0105] Hereinafter, embodiments of the above-mentioned chemical strengthening processing step for carrying out the chemical strengthening process and the cooling step will be explained.

[0106] In the present embodiments, a glass substrate for a magnetic disc and a magnetic disc were manufactured through th following steps. Especially, in (6) chemical strengthening processing step, chemical strengthening process and cooling step according to the present embodiment are applied.

[0107]

(1) Shape processing step and first wrapping step

First, aluminosilicate glass is cast into disc-shape by direct press using upper, lower, and body molds to obtain a plate-shaped amorphous glass. Here, as the aluminosilicate glass, glass for chemical strengthening is used. The disc-shaped glass substrate for a magnetic disc may be obtained by, other than the direct press, cutting the substrate out by a grinding wheel from a sheet glass formed by down draw method or float method. Here, as the aluminosilicate glass, chemical strengthening glass including; 58 to 75 percent by weight of SiO_2; 5 to 23 percent by weight of Al_2O_3; 3 to 10 percent by weight of Li_2O, and 4 to 13 percent by weight of Na_2O, is used.

[0108] Next, both main surfaces of the plate glass is

wrapping processed to make a disc-shaped base glass material. The wrapping process is carried out by an apparatus for both surfaces wrapping using planetary gear mechanism and alumina system loose grain is used. Specifically, wrapping platen is pressed both from top and bottom of the plate glass, grinding fluid containing loose grain is supplied on the main surface of the plate glass, and they are relatively moved to carry out the wrapping process. By this wrapping process, a glass base material having smooth main surface is obtained.

[0109]

(2) Cutting step (coring, forming)

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

[0110]

(3) Second wrapping step

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

becomes possible to finish following polishing step of the main surface in a short period of time.

[0111]

(4) Edge polishing step

Next, by brush polishing method, outer circumference edge surface of the glass substrate is mirror polished. At this time, slurry including cerium oxide abrasive grain (loose grain) is used as polishing grain.

[0112]

(5) Main surface polishing step

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

[0113] The glass substrate after the first polishing step was sequentially dipped in cleansing tanks of neutral detergent, pure water, and isopropyl alcohol (IPA) to be cleansed.

[0114] Next, second polishing step was performed as the main surface polishing step. The second polishing step is aimed at finishing the main surface to have a mirror surface. In the second polishing step, main surface was polished by an apparatus for both surfaces wrapping using planetary gear mechanism, using flexible resin foam polisher. As polishing liquid, cerium oxide abrasive grain having finer grain than the cerium

oxide abrasive grain used in the first polishing step was used.

[0115] The glass substrate after the second polishing step was sequentially dipped in cleansing tanks of neutral detergent, pure water, and isopropyl alcohol (IPA) to be cleansed. Here, ultrasonic wave was applied to the tanks.

[0116]

(6) Chemical strengthening processing step

Next, chemical strengthening was conducted to the glass substrate after the above-mentioned wrapping and polishing steps. By carrying out the chemical strengthening process, it becomes possible to generate strong compression stress on the surface layer portion of the magnetic disc substrate and to improve impact resistance.

[0117] The chemical strengthening was conducted by preparing chemical strengthening processing solvent in which 60% of potassium nitrate and 40% of sodium nitrate are mixed. The chemical solution was heated to 400°C and the cleansed glass substrate was heated to 300°C. Then, the glass substrate was dipped into the chemical strengthening processing solvent for about 3 hours. The dipping was conducted by use of the glass substrate holder according to the present embodiment. The glass substrate holder holds a plurality of glass substrate on edge surface. Therefore, it is possible to chemically strengthen the whole of the surface of the glass substrate.

[0118] By dipping the glass substrate into the chemical strengthening processing solvent, 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 processing solvent and the glass substrate is strengthened. Thickness of compression stress layer formed on the surface layer of the glass substrate was between about 100 μm and 200 μm.

[0119] In case of applying a glass substrate according to the present embodiment to such chemical strengthening process, because there occurs no difference between heating speed of the glass substrate and that of the glass substrate holder dipped in the chemical strengthening processing solvent, a glass substrate having fine flatness is produced.

[0120] Subsequently, the glass substrate after the chemical strengthening processing step is dipped into a water tank of 20°C to be cooled down while the glass substrate is stored in the glass substrate holder of the present embodiment and was kept in the tank for about 10 minutes. Then, the cooled glass substrate is dipped in concentrated sulfuric acid heated to about 40°C to be cleansed. Moreover, the glass substrate after cleansing by the concentrated sulfuric acid is sequentially dipped into tanks of pure water and IPA to be cleansed. Here, ultrasonic wave was applied to the tanks.

[0121] Because the glass substrate holder according to the present embodiment does not cause difference between heating speed of the glass substrate and the glass substrate holder, it is possible to produce a glass substrate having more superior flatness.

[0122] As mentioned above, by carrying out the first

wrapping step, the cutting step, the second wrapping step, the edge surface polishing step, the main surface polishing step, and the chemical strengthening processing step, a flat and smooth glass substrate for a magnetic disc having high rigidity is obtained.

[0123]

[Evaluation]

A glass substrate to which the chemical strengthening processing step and the cooling step were carried out by use of the above-mentioned glass substrate holder and a glass substrate to which the chemical strengthening processing step and the cooling step were carried out by use of a conventional glass substrate holder (a glass substrate holder without function to heat glass substrate surface which is the portion not in contact with the holder) were measured by use of a profilometer (Optiflat (a product of Phase Shift Technology)). As a result, difference between the maximum value and minimum value in a direction orthogonal to the main surface of the substrate of embodiment 1 was 4μm while that of the comparative example was 10μm.

[0124]

(7) Precision cleaning step

Next, precision cleaning of the glass substrate for a magnetic disc was carried out. This is for the purpose of removing residue of polishing solution or foreign metallic contamination which may cause head crush or thermal asperity and of obtaining a clean glass substrate having a flat surface.

As the precision cleaning process, following after cleaning by alkaline solution, water rinse cleaning and IPA cleaning steps were carried out.

[0125]

(8) Magnetic disc manufacturing step

On the both surfaces of the glass substrate obtained through the above-mentioned steps, an attachment layer including Cr alloy, a soft magnetic layer including CoTaZr alloy, a ground layer including Ru, a vertical magnetic recording layer including CoCrPt alloy, a protection layer including carbon hydroxide, and a lubrication layer including perfluoropolyether are sequentially formed to manufacture a vertical magnetic recording disc. Here, the present configuration is an example of a vertical magnetic disc. However, a magnetic layer or the like may be included as an in-plane magnetic disc.

[0126] It was confirmed that the magnetic disc thus obtained had no failure by a foreign object on a film such as a magnetic layer. Moreover, when glide test was conducted, hit (a head grazing convex portion on the surface of the magnetic disc) or crush (a head hitting convex portion on the surface of the magnetic disc) was not observed. Further, when replaying test was conducted using the magnetoresistive head, malfunction caused by thermal asperity was not observed.

[0127]

(Embodiment 2)

The above-mentioned chemical strengthening processing

step was carried out with a glass substrate held by a conventional glass substrate holder. Other than a change in cooling method of the glass substrate following the chemical strengthening process step, same procedures were taken as in the Embodiment 1 to manufacture a glass substrate for a magnetic disc.

[0128] That is, a glass substrate to which the chemical strengthening processing step was carried out is pulled up in a condition where the glass substrate is held by a glass substrate holder used in the chemical strengthening processing step and the substrate holder was cooled by air so that a holding unit of the glass substrate holder in contact with the glass substrate is cooled. Then, after the substrate was cooled to predetermined temperature (100°C or less), the substrate was dipped into a water tank of 20°C to be cooled down and was kept in the tank for about 10 minutes.

[0129]

[Evaluation]

A glass substrate manufactured according to the above-mentioned Embodiment 2 and a glass substrate to which the chemical strengthening processing step and the cooling step were carried out by use of a conventional glass substrate holder (a glass substrate holder without function to heat glass substrate surface which is the portion not in contact with the holder) were measured by use of a profilometer (Optiflat (a product of Phase Shift Technology)), similarly to Embodiment 1. As a result, difference between the maximum value and

minimum value in a direction orthogonal to the main surface of the substrate of embodiment 2 was 6μm while that of the comparative example was 10μm.

[0130] With reference to attached figures, preferred embodiments of the present invention have been explained above. However, it is needless to say that the present invention is not limited to the examples. It is to be understood that modifications and corrections will be apparent to those skilled in the art within the scope and spirit of the following claims and all modifications and corrections are therefore intended to be embraced by the technical scope of the present invention.

[0131] For example, in the above-mentioned embodiments, only noncontact portion of a glass substrate is heated or cooled. However, whole of the glass substrate including contact portion and noncontact portion may be heated or cooled to equalize change of temperature of the glass substrate and a holding unit also enables to obtain similar effect. For example, in the heating of the noncontact portion, heat flows into the contact portion from the holding unit and the noncontact portion to uniformize temperature distribution in the surface of the glass substrate. However, as mentioned here, it is possible to stop flow of heat from the holding unit to the glass substrate and to prevent bias in temperature distribution of the glass substrate by heating the whole of the glass substrate to equalize the temperature of the holding unit and the glass substrate.

Industrial Applicability

[0132] The present invention can be applied to a manufacturing method of a glass substrate for a magnetic disc including a chemical strengthening process step or a cooling step thereafter and a manufacturing method of a magnetic disc.

CLAIMS

1. A manufacturing method of a glass substrate for a magnetic disc comprising a cooling step for cooling a disc-shaped glass substrate caused to have heat by chemical strengthening process for exchanging ions by dipping the substrate into chemical strengthening process solution;

wherein a surrounding medium of the glass substrate is cooled while the glass substrate is held by a holding unit of the glass substrate holder; and

a noncontact portion which is a part of the glass substrate and is not in contact with the holding unit is heated so that change of temperature of the glass substrate is controlled to be uniform in the surface of the substrate.

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

wherein heating of the noncontact portion is carried out by radiant heat from a heat sink provided opposite to the glass substrate.

3. The manufacturing method of a glass substrate for a magnetic disc according to claim 1, further comprising the steps of:

detecting temperature of the holding unit;

detecting temperature of the noncontact portion;

calculating heating amount corresponding to difference in temperature between the holding unit and the noncontact portion; and

heating the noncontact portion heated with the heating amount thus calculated.

4. A manufacturing method of a glass substrate for a magnetic disc comprising a cooling step for cooling a disc-shaped glass substrate caused to have heat by chemical strengthening process for exchanging ions by dipping the substrate into chemical strengthening process solution;

wherein a surrounding medium of the glass substrate is cooled while the glass substrate is held by a holding unit of the glass substrate holder; and

the holding unit is further cooled so that change of temperature of the glass substrate is controlled to be uniform in the surface of the substrate.

5. The manufacturing method of a glass substrate for a magnetic disc according to claim 4,

wherein temperature of the noncontact portion which is a part of the glass substrate and is not in contact with the holding unit is detected;

temperature of the holding unit is detected;

cooling amount is calculated corresponding to difference in temperature between the holding unit and the noncontact portion;

and the holding unit is cooled with the cooling amount thus calculated.

6. The manufacturing method of a glass substrate for a magnetic disc according to any one of claims 1 to 5,

wherein the holding unit may have material and/or shape which allows change of temperature becomes similar to that of the glass substrate.

7. The manufacturing method of a glass substrate for a magnetic disc according to any one of claims 1 to 5,

wherein a front surface side and a rear surface side of an outer periphery of the glass substrate are uniformly attached to the holding unit.

8. A manufacturing method of a glass substrate for a magnetic disc comprising a cooling step for cooling a disc-shaped glass substrate caused to have heat by chemical strengthening process for carrying out ion exchange by dipping the glass substrate into chemical strengthening processing solvent,

wherein the glass substrate is cooled while being held by a holding unit of a glass substrate holder for storing a glass substrate and while the noncontact portion which is a part of the glass substrate and is not in contact with the holding unit is heated so that change of temperature of the glass substrate becomes uniform in the surface thereof.

9. The manufacturing method of a glass substrate for a magnetic disc according to claim 8,

wherein cooling step for the glass substrate holder is carried out while the holder holds the heated glass substrate after the chemical strengthening process for the glass substrate is carried out in a condition where the glass substrate is held by the glass substrate holder.

10. The manufacturing method of a glass substrate for a magnetic disc according to any one of claims 1 to 9,

wherein at least a magnetic layer is formed on a glass substrate for a magnetic disc manufactured by the above-mentioned manufacturing method of a glass substrate for a magnetic disc.