

DESCRIPTION

[Title of Invention]

METHOD FOR MANUFACTURING MAGNETIC-DISK GLASS SUBSTRATE

5

[Technical Field]

[0001] The present invention relates to a method for manufacturing a magnetic-disk glass substrate.

[Background Art]

10 [0002] Conventionally, a glass substrate has been preferably used in a magnetic disk used as one type of information recording medium. Nowadays, in order to meet the demand for an increase in the storage capacity of hard disk drive apparatuses, attempts have been made to increase the magnetic recording density. Accompanying this, the magnetic recording information
15 area has been made smaller by making the flying height of the magnetic head from the magnetic recording surface extremely low. In such a magnetic-disk glass substrate, in order to achieve a lower flying height of the magnetic head, which is necessary for a high-recording density hard disk drive apparatus, a decrease in surface unevenness of the substrate, and in particular, a decrease
20 in microwaviness is in increasing demand. Moreover, because a magnetic layer is formed on a main surface of the glass substrate, the main surface are strictly managed such that unnecessary foreign matter resulting from an organic component does not remain on the main surface. Thus, it is very important to perform cleaning processing and drying processing on the main
25 surface of the glass substrate that has undergone final polishing.

[0003] For example, cleaning processing and drying processing for preventing glass from being modified and deteriorating (so-called bloom) due to foreign matter attached to a main surface of a magnetic-disk glass substrate on which texture is formed have been known (PLT 1).

30 Specifically, when the magnetic-disk glass substrate is manufactured,

in the cleaning processing, at least cleaning is performed using an aqueous solution containing pure water or water as the main component, and thereafter, cleaning is performed using, as the cleaning liquid, a liquid that contains a water-soluble solvent having a boiling point lower than that of water as the main component, and contains water in an amount of 1.0 wt% or less. In the drying processing, at least dehydration processing in which the magnetic-disk glass substrate and vapor of the liquid that contains the water-soluble solvent having a boiling point lower than that of water as the main component are brought into contact with each other is performed. The liquid in this dehydration processing contains moisture in an amount of 1.0 wt% or less.

[Citation List]

[Patent Literature]

[0004] [PLT1]: Japanese Patent 5032758

[Summary of Invention]

15 [Technical Problem]

[0005] However, in recent years, there has been a problem in that a defect that looks like a cloudy stain appears in a partial region on the circumference in the vicinity of an outer circumferential side edge surface on a main surface of the glass substrate on which cleaning processing and drying processing have been performed. Hereinafter, this defect will be referred to as cleaning stains. These cleaning stains are different from the above-described bloom formed by the entire main surface turning white and cloudy due to a reaction between water in the air and an alkali metal component in the main surface of the glass, and the cleaning stains are thought to be what partially remains on the main surface at the time of the drying processing. Such cleaning stains are not preferable in light of the fact that a magnetic disk is produced by forming a magnetic film on the main surface of the glass substrate.

[0006] In view of this, an object of the present invention is to provide a method for manufacturing a magnetic-disk glass substrate with which the appearance of cleaning stains on a main surface of the glass substrate can be suppressed

when the magnetic-disk glass substrate is manufactured.

[Solution to Problem]

[0007] As a result of performing studies on the composition and the like of the cleaning stains in order to find the cause of the cleaning stains, the inventor of the present application found that the cleaning stains were derived from
5 cleaning agent used in cleaning processing and foreign matter composed of an organic component attached to the glass substrate before cleaning processing, and that a portion of this organic component remained on the glass substrate in drying processing. In view of this, as a result of studies on methods with
10 which organic components can be sufficiently removed in the cleaning processing and the drying processing even from a glass substrate having a surface to which an organic component is attached, the inventor of the present application achieved the invention having the following aspects.

[0008] That is, one aspect of the present invention is a method for
15 manufacturing a magnetic-disk glass substrate. The manufacturing method includes the following aspects.

[0009] Aspect 1

A method for manufacturing a magnetic-disk glass substrate, including:
cleaning processing for cleaning a surface of the glass substrate; and
20 drying processing for drying the surface after the cleaning processing,
in which the cleaning processing includes first liquid treatment in which the glass substrate is immersed in a first liquid containing water and a water-soluble solvent having a boiling point lower than that of water, and
the first liquid contains the water-soluble solvent as a main component,
25 and water in an amount of 3.0 wt% or more.

[0010] Aspect 2

The method for manufacturing a magnetic-disk glass substrate according to Aspect 1, in which
the drying processing is processing in which the glass substrate is
30 disposed in vapor of a second liquid containing water and a water-soluble

solvent having a boiling point lower than that of water, at least a portion of droplets on the glass substrate are allowed to drip from the glass substrate while droplets are allowed to form on the surface of the glass substrate, and the glass substrate is dried, and

5 a water content of the second liquid is lower than a water content of the first liquid.

[0011] Aspect 3

The method for manufacturing a magnetic-disk glass substrate according to Aspect 2, in which the water content of the second liquid is more
10 than 1.0 wt%.

[0012] Aspect 4

A method for manufacturing a magnetic-disk glass substrate, including:
cleaning processing for cleaning a surface of the glass substrate; and
drying processing for drying the surface after the cleaning processing,
15 in which the drying processing includes disposing the glass substrate in vapor of a second liquid containing water and a water-soluble solvent having a boiling point lower than that of water, and allowing a portion of droplets on the glass substrate to drip from the glass substrate while allowing droplets to form on the surface of the glass substrate, and

20 the second liquid contains the water-soluble solvent as a main component, and the water in an amount of more than 1.0 wt%.

[0013] Aspect 5

The method for manufacturing a magnetic-disk glass substrate according to Aspect 4, in which

25 the cleaning processing includes first liquid treatment in which the glass substrate is immersed in a first liquid containing water and a water-soluble solvent having a boiling point lower than that of water, and

a water content of the first liquid is higher than a water content of the second liquid.

30 [0014] Aspect 6

The method for manufacturing a magnetic-disk glass substrate according to any one of Aspects 1 to 3, and 5, in which

the glass substrate contains an alkali metal component, and

the cleaning processing includes water treatment in which the surface
5 is cleaned by immersing the glass substrate in water having a temperature of 40°C or more and 50°C or less.

[0015] Aspect 7

The method for manufacturing a magnetic-disk glass substrate according to Aspect 6, in which the glass substrate undergoes processing in the
10 order of the water treatment, the first liquid treatment, and the drying processing.

[0016] Aspect 8

The method for manufacturing a magnetic-disk glass substrate according to any one of Aspects 1 to 7, in which the water-soluble solvent is
15 isopropyl alcohol.

[0017] Aspect 9

The method for manufacturing a magnetic-disk glass substrate according to any one of Aspects 1 to 8, in which a total content of alkali metal components in the glass substrate is 22.0 mol% or less.

20 [Advantageous Effects of the Invention]

[0018] With the above-described method for manufacturing a magnetic-disk substrate, the appearance of cleaning stains on a main surface of a glass substrate can be suppressed when the magnetic-disk glass substrate is manufactured.

25 [Brief Description of Drawings]

[0019] FIG. 1 is a diagram schematically illustrating cleaning processing and drying processing in this embodiment.

[Description of Embodiments]

[0020] Hereinafter, a method for manufacturing a magnetic-disk glass
30 substrate according to the present invention will be described in detail.

[0021] In the present embodiment, a magnetic-disk glass substrate has a disk shape, and a central portion is hollowed out in a concentric shape so that the substrate has a ring shape. The magnetic-disk glass substrate rotates using the center of this ring shape as the rotation axis. The magnetic disk is
 5 obtained by stacking a magnetic layer and the like on the magnetic-disk glass substrate. For example, an adherent layer, a soft magnetic layer, a nonmagnetic base layer, a vertical magnetic recording layer, a protecting layer, a lubricant layer, and the like are formed on the glass substrate. Accordingly, a magnetic disk is manufactured. Thus, surfaces of the magnetic-disk glass
 10 substrate are strictly managed so as to be cleaned. Such a magnetic-disk glass substrate is produced with the following manufacturing method.

Hereinafter, each process in this method for manufacturing a glass substrate will be described.

[0022] (a) Glass blank molding processing

15 A glass blank is plate-shaped glass that serves as the base for a glass substrate. A float method is used to mold the glass blank, for example. In the glass blank molding processing, first, the plate-shaped glass is obtained by continuously pouring molten glass into a bath filled with molten metal such as tin. The molten glass moves in a traveling direction in the bath where the
 20 temperature is strictly controlled, and ultimately plate-shaped glass with a desired thickness and width is formed. A plate-shaped glass blank with a predetermined shape (a quadrangular shape in a plan view, for example) from which a magnetic-disk glass substrate is to be made is cut out from this plate-shaped glass.

25 Also, the plate-shaped glass blank can also be molded with a press molding method, for example, instead of the float method. Furthermore, the plate-shaped glass blank can be manufactured using a known manufacturing method such as a down draw method, a redraw method, or a fusion method. A disk-shaped glass blank from which a magnetic-disk glass substrate is to be
 30 made is cut out by appropriately shaping the plate-shaped glass manufactured

with these known manufacturing methods.

[0023] (b) Shape processing

Next, in the shape processing, a disk-shaped glass substrate having a circular through hole is produced by forming a circular hole using a known processing method after the glass blank molding processing. Thereafter, chamfering may be further performed. Also, the main surfaces may be ground in order to adjust the thickness, reduce the flatness, or the like.

[0024] (c) First polishing processing

Next, first polishing processing is performed on the main surfaces of the glass substrate. The first polishing processing is performed in order to mirror-polish the main surfaces. Specifically, the main surfaces on both sides of the glass substrate are polished while holding the glass substrate in a holding hole provided in a holding member (carrier) that is attached to a double-side polishing apparatus. The machining allowance for first polishing is from about several micrometers to 100 μm , for example. The first polishing processing is performed in order to eliminate blemishes and distortions that remain on the main surfaces and to adjust minute unevenness of the surface, for example. Note that in order to further reduce or more finely adjust surface unevenness, the first polishing processing may be divided into a plurality of polishing processes.

[0025] In the first polishing processing, the glass substrate is polished while a polishing slurry is supplied, using a known double-side polishing apparatus that includes an upper surface plate, a lower surface plate, an internal gear, carriers, and a sun gear, and has a planetary gear mechanism. In the first polishing processing, a polishing slurry containing polishing abrasive particles (loose abrasive particles) is used. Abrasive particles (particle size: diameter is about 0.3 to 3 μm) of cerium oxide, zirconia, or colloidal silica, for example, are used as the loose abrasive particles that are used in the first polishing processing. In the double-side polishing apparatus, the glass substrate is sandwiched between the pair of upper and lower surface plates. Tabular

polishing pads (resin polishers, for example) that each have an annular shape overall are attached to the upper surface of the lower surface plate and the bottom surface of the upper surface plate. The glass substrate and the surface plates are moved relative to each other by moving one or both of the upper
5 surface plate and the lower surface plate, and thereby both main surfaces of the glass substrate are polished.

[0026] (d) Chemical strengthening processing

The glass substrate can be chemically strengthened as appropriate. A molten liquid obtained by heating potassium nitrate, sodium nitrate, or a
10 mixture thereof, for example, to from 300°C to 500°C can be used as a chemical strengthening liquid. The glass substrate is then immersed in the chemical strengthening liquid for 1 hour to 10 hours, for example. The timing at which the chemical strengthening is performed can be determined as appropriate. The chemical strengthening processing is not an essential process and is not
15 necessarily performed.

[0027] (e) Second polishing (final polishing) processing

Next, second polishing processing is performed on the glass substrate that has undergone the chemical strengthening processing. The second polishing processing is performed in order to mirror-polish the main surfaces.
20 In second polishing as well, a double-side polishing apparatus having a configuration similar to that of the double-side polishing apparatus used in first polishing is used. The machining allowance for second polishing is about 0.5 μm to 10 μm , for example.

In the second polishing processing, polishing is performed using a
25 slurry containing loose abrasive particles. Colloidal silica is preferably used as the loose abrasive particles. The average particle diameter of the colloidal silica is 5 nm or more and 50 nm or less, for example. This process makes it possible to set an arithmetic average roughness Ra of a main surface of the glass substrate to 0.15 nm or less, and preferably 0.1 nm or less, and to set a
30 root mean square roughness Rq of microwaviness at a wavelength of 50 to 200

μm to 0.06 nm or less. Next, cleaning processing and drying processing are performed such that no organic components remain as a film on the main surfaces of the glass substrate that has a surface roughness that satisfies quality requirement for a magnetic-disk glass substrate, for example.

5 [0028] (f) Cleaning processing and drying processing

FIG. 1 is a diagram schematically illustrating cleaning processing for a surface of a glass substrate and drying processing for the surface of the glass substrate, which is performed after the cleaning processing in the present embodiment.

10 Here, one process in the cleaning processing includes first liquid treatment in which the glass substrate is immersed in a first liquid containing water and a water-soluble solvent having a boiling point lower than that of water. At this time, the first liquid contains the water-soluble solvent as the main component, and water in an amount of 3.0 wt% or more. Furthermore,
 15 the first liquid preferably contains water in an amount of 5 wt% or more. Although there is no particular limitation on the upper limit of the water content in the first liquid, for example, the upper limit is 40 wt%, preferably 35 wt%, and more preferably 30 wt%. The main component means that the content of the main component is more than 50 wt%. Here, IPA (isopropyl
 20 alcohol) is suitably used as the water-soluble solvent having a boiling point lower than that of water.

Furthermore, in the drying processing performed after the cleaning processing, the glass substrate is disposed in vapor of a second liquid containing water and a water-soluble solvent having a boiling point lower than
 25 that of water. At this time, a portion of droplets on the glass substrate are allowed to drip from the glass substrate while droplets are allowed to form on the surface of the glass substrate. Thereafter, a portion of the droplets remaining on the glass substrate evaporate. At this time, the second liquid contains the water-soluble solvent as the main component, and water in an
 30 amount of more than 1.0 wt%. The water content is preferably 1.1 wt% or

more. More preferably, the water content is 1.3 wt% or more. On the other hand, the water content is preferably 5.0 wt% or less, and the water content is more preferably 2.8 wt% or less. Also, IPA (isopropyl alcohol) is suitably used as the water-soluble solvent having a boiling point lower than that of water.

5 The main component means a component having a content of more than 50 wt%.

Hereinafter, description will be given using IPA as an example of the water-soluble solvents in the first liquid and the second liquid.

[0029] Hereinafter, the cleaning processing and the drying processing will be
10 described in the stated order.

As shown in FIG. 1, a glass substrate 10 on which final polishing processing has been performed is sequentially sent to an alkaline cleaning tank 12, a pure water cleaning tank 14, a neutral detergent cleaning tank 16, a pure water cleaning tank 18, and an IPA cleaning tank 20. When the glass
15 substrate 10 is immersed in each liquid in the tanks, ultrasound cleaning may be performed by applying ultrasound to the glass substrate 10 and the liquid, in some cases.

[0030] In order to remove foreign matter remaining on main surfaces of the glass substrate 10 from the surfaces of the glass substrate 10, an alkaline
20 solution is used in the alkaline cleaning tank 12. At this time, it is preferable that the cleaning liquid in the alkaline cleaning tank 12 is a solution that is as weakly alkaline as possible so as to avoid an increase in surface roughness due to progress in etching of the main surfaces of the glass substrate 10.

Next, the glass substrate 10 is immersed in water and rinsed in the
25 pure water cleaning tank 14.

Thereafter, the glass substrate is immersed in a solution of a neutral detergent and surfaces of the glass substrate including the main surfaces are cleaned in the neutral detergent cleaning tank 16. This makes it possible to remove foreign matter composed of an organic component attached to the main
30 surfaces, and the like.

Thereafter, the glass substrate 10 is immersed in water and rinsed in the pure water cleaning tank 18.

Furthermore, the glass substrate 10 is immersed in a solution (first liquid) containing IPA as the main component in the IPA cleaning tank 20.

- 5 Use of IPA as the main component in the solution in the present embodiment is because IPA is suitably used in the later-described drying processing. Components in the solvent in the drying processing tank 22 do not easily change due to the same type of solvent as that in the drying processing tank 22 being used in the IPA cleaning tank 20, and stable drying processing is possible.
- 10 Containing IPS as the main component refers to containing IPA in the solution in an amount of more than 50 wt%.

Next, drying processing is performed with vapor of IPA in the drying processing tank 22 so as to dry the glass substrate 10.

- [0031] In the drying processing tank 22, a water-containing solution (second liquid) containing IPA and water is accumulated in a bottom portion and forms liquid. The second liquid is heated to a boiling temperature (82.4°C) of IPA and the IPA is in a boiling state, a gas phase in the drying processing tank 22 is filled with vapor of IPA and water. The glass substrate 10 is disposed in the gas phase in this drying processing tank 22. The second liquid contains IPA
- 15 as the main component. The main component refers to IPA being contained in the second liquid in an amount of more than 50 wt%.

[0032] In the drying processing in the present embodiment, the following mechanism is inferred.

- In the drying processing, when the glass substrate 10 is disposed in the vapor of the second liquid containing IPA and water, the temperatures of the surfaces of the glass substrate 10 are lower than that of the vapor of the second liquid, and thus the vapor collects on the surfaces of the glass substrate 10 and forms droplets on the surfaces of the glass substrate 10. At this time, a film of the first liquid containing IPA as the main component remains on the main
- 25 surfaces of the glass substrate 10 due to processing in which the glass substrate
- 30

10 is immersed in the first liquid in the IPA cleaning tank 20. In the drying processing, many droplets of the second liquid are newly formed on the surfaces of the glass substrate 10, and thus the remaining first liquid is allowed to drip from the glass substrate 10 and drips into the second liquid due to the formation of these droplets of the second liquid. Accordingly, the first liquid remaining on the surfaces of the glass substrate 10 is substituted with the second liquid. Thereafter, the glass substrate 10 is gradually warmed by the temperature of the vapor and no droplets are formed on the surfaces of the glass substrate 10. In this manner, the surfaces of the glass substrate 10 are gradually dried. The surfaces of the glass substrate 10 that has been removed from the drying processing tank 22 are in a dry state, and a magnetic-disk glass substrate can be obtained.

[0033] In the cleaning processing that is performed before such drying processing, the water content in the first liquid in the IPA cleaning tank 20 is 3.0 wt% or more. The upper limit of the water content is 40 wt%, preferably 35 wt%, and more preferably 30 wt%, for example. Defining the water content in this manner makes it possible to suppress the appearance of cleaning stains on the glass substrate 10 that has undergone the drying processing.

Also, the second liquid used in the above-described drying processing contains IPA as the main component, and contains water in an amount of more than 1.0 wt%, and preferably contains water in an amount of 1.1 wt% or more. The upper limit of the water content is preferably 5.0 wt%, and more preferably 2.8 wt% or less.

The appearance of the above-described cleaning stains can be suppressed by the second liquid containing water in an amount of more than 1.0 wt% in this manner.

Furthermore, use of the first liquid and the second liquid that contain water in the cleaning processing in the above-described numerical value ranges makes it possible to further suppress the appearance of the above-described cleaning stains.

The cleaning stains are derived from residue of an organic component attached to a surface of the glass substrate 10 before the cleaning processing or an organic component of a detergent that is used in an aqueous solution-based cleaning tank. Moreover, the appearance of the cleaning stains can be thought
5 as follows.

That is, the residue of the organic component attached to the surface of the glass substrate 10 or the organic component of the detergent is taken into the water in the pure water cleaning tank 18 or the first liquid in the IPA cleaning tank 20, and a portion thereof attaches to a surface of the glass
10 substrate 10 and moves to the subsequent tank. The glass substrate 10 having the surface to which the residue of this organic component or foreign matter composed of the organic component in the detergent (hereinafter also referred to as "organic foreign matter") is attached is taken into the IPA cleaning tank 20 and the drying processing tank 22. However, this organic
15 foreign matter is not likely to be removed by IPA droplets in the drying processing tank 22. Even if the above-described organic foreign matter is removed from the surface of the glass substrate 10 and the droplets contains the removed organic foreign matter, a support rod for disposing the substrate in vapor in the gas phase supports the outer circumferential edge surface of the
20 glass substrate 10 from below, and thus liquid accumulation is formed in a portion at which the support rod and the outer circumferential edge surface are in contact with each other. In this liquid accumulation, liquid exchange caused by droplets hardly occurs, and the liquid accumulation is dried in continuous contact with the outer circumferential edge surface of the glass
25 substrate 10. Thus, cleaning stains are formed in a region that is in contact with the support rod on the main surface of the glass substrate 10 in the vicinity of the outer circumferential edge surface of the glass substrate 10.

Furthermore, in order to set the arithmetic average roughness Ra of surface roughness of a main surface of the glass substrate 10 to 0.2 nm or less,
30 a weakly alkaline detergent or a neutral detergent is used in cleaning

processing having a weak etching power on the main surface, but residue of the organic component attached to the glass substrate 10 cannot be sufficiently removed with such a detergent in some cases. Thus, in recent years, it is thought that the glass substrate 10 to which organic foreign matter or the like is attached has been likely to be taken into the IPA cleaning tank 20. As a result, the organic component has been accumulated also in the IPA cleaning tank 20, and when the glass substrate 10 is taken into the drying processing tank 22 from the IPA cleaning tank 20, the organic foreign matter has attached to a surface of the glass substrate 10 or has tended to remain. Furthermore, the drying processing in the drying processing tank 22 is for drying the glass substrate 10 and has a weak cleaning function. As a result, the glass substrate 10 has been dried with the residue of the organic component or foreign matter composed of the organic component of the detergent remaining on the surface of the glass substrate 10, and cleaning stains have been formed.

[0034] In the present embodiment, the water content in the first liquid used in the IPA cleaning tank 20 is set to 3.0 wt% or more. The water content is, for example, 40 wt% or less, preferably 35 wt% or less, and more preferably 30 wt% or less.

Setting the water content in the first liquid used in the IPA cleaning tank 20 immediately before the drying processing to the above-described range suppresses adsorption (re-attachment) of organic foreign matter that has been taken into the first liquid via the glass substrate 10 to surfaces of the glass substrate 10. Because water has a higher polarity than that of IPA, it is possible to suppress attachment of the organic foreign matter to the surfaces of the glass substrate 10. Thus, the amount of the organic foreign matter that attaches to the glass substrate that is taken into the drying processing is reduced. Therefore, it is possible to suppress the appearance of cleaning stains on the main surfaces of the glass substrate 10.

Also, in the present embodiment, in addition to IPA, the second liquid contains water in an amount of more than 1.0 wt% in the drying processing

tank 22. It is conceivable that since water has a higher polarity than that of IPA, water easily adsorbs on residue of an organic component or foreign matter composed of an organic component (hereinafter, referred to as organic foreign matter) in a detergent. Furthermore, because the surfaces of the glass substrate are highly hydrophilic, water easily enters the periphery of the organic foreign matter that is strongly attached to the surface of the glass substrate 10 or a gap between the organic foreign matter and the glass substrate. Thus, the organic foreign matter is easily dissolved in water that forms droplets, and the residue of the organic component and foreign matter composed of the organic component in the detergent are easily removed from the glass substrate 10 due to dripping of these droplets. As a result, in the drying processing, it is possible to suppress the appearance of cleaning stains constituted by the residue of the organic component or foreign matter composed of the organic component in the detergent.

The water content in the second liquid is more than 1.0 wt%, and preferably 1.1 wt% or more in light of the fact that the appearance of the cleaning stains is suppressed. More preferably, the water content is 1.3 wt% or more. Also, the water content is preferably 5.0 wt% or less, and more preferably 2.8 wt% or less in light of the fact that water droplets sufficiently evaporate and are sufficiently dried in the drying processing tank 22.

[0035] As described above, in the cleaning processing, a neutral detergent or a weakly alkaline detergent that has a weak etching power is used in order to suppress an increase in surface roughness of the glass substrate that has undergone the final polishing processing. As a result of this, the glass substrate 10 having a surface to which residue of an organic component is attached tends to be taken into the drying processing tank 22. That is, in the cleaning processing, a detergent is selected such that a change in the surface roughness Ra (arithmetic average roughness) of a main surface of the glass substrate 10 before and after the cleaning processing is 0.05 nm or less. In such a case, setting the water content in the first liquid used in the IPA

cleaning tank 20 to 3.0 wt% or more and 40 wt% or less, preferably 35 wt% or less, more preferably 30 wt% or less makes it possible to suppress the attachment of the residue or foreign matter composed of the organic component to the surfaces of the glass substrate 10 in the IPA cleaning tank 20. Also, setting the water content to more than 1.0 wt% and using the second liquid containing IPA as the main component in the drying processing tank 22 make it possible to remove the organic foreign matter from the main surfaces of the glass substrate 10 and thus to suppress the appearance of cleaning stains.

[0036] Conventionally, in order to prevent bloom, the water content in the second liquid in the drying processing tank 22 has been set to 1.0 wt% or less. However, in recent years, the glass composition has changed, for example, the content of alkali metal components such as Li_2O , Na_2O , and K_2O in the glass composition of the glass substrate 10 is 22 mol% or less, and preferably 20 mol% or less, and thus compared to the conventional glass composition, the content of the alkali metal components is low. Therefore, even if the water content in the second liquid is set to more than 1.0 wt%, bloom is unlikely to appear.

Also, the glass substrate 10 contains alkaline earth metal components such as MgO , CaO , SrO , and BaO . Thus, even if the water content in the first liquid is set to more than 1.0 wt%, bloom is unlikely to appear.

Also, texture is not formed on the main surfaces as with the conventional glass substrate, and thus bloom is unlikely to appear. It is thought that if texture is formed, multiple grooves were intentionally formed on a surface, and thus alkali metal components and the like were easily eluted from the surface, and bloom was likely to appear. The glass substrate 10 of the present embodiment has smooth surfaces with the main surfaces having no texture. Therefore, the surface roughness of the glass substrate 10 of the present embodiment has no anisotropy, and is isotropic.

[0037] In the present embodiment, in order to effectively suppress the appearance of cleaning stains, in addition to setting the water content in the

first liquid used in the IPA cleaning tank 20 to 3.0 wt% or more, the water content in the second liquid in the drying processing tank 22 is preferably set to more than 1.0 wt%. In this case, droplets containing IPA and water are formed in the drying processing tank 22. As described above, since water has a higher polarity than that of IPA, water easily adsorbs on the residue of the organic component and foreign matter composed of the organic component in the detergent, and the glass substrate is hydrophilic. Thus, water easily enters the periphery of the organic foreign matter attached to the surface of the glass substrate 10 or a gap between the organic foreign matter and the glass substrate. Thus, the organic foreign matter is easily dissolved in droplets containing water, and the organic foreign matter is easily removed from the glass substrate 10 due to dripping of these droplets. This makes it possible to effectively suppress the appearance of the cleaning stains constituted by the organic foreign matter in the drying processing.

If the water content in the second liquid exceeds 5.0 wt%, water droplets do not sufficiently evaporate in the drying processing tank 22, and the drying processing is not sufficiently performed. On the other hand, if the water content in the second liquid is less than 1.0 wt%, the appearance of the cleaning stains cannot be suppressed. The water content in the second liquid is more preferably 2.8 wt% or less.

[0038] Also, the water content of the second liquid in the drying processing tank 22 is preferably lower than the water content of the first liquid in the IPA cleaning tank 22 in light of the fact that the cleaning stains can be suppressed and the glass substrate 10 can be dried. In the case where the water content of the second liquid is greater than or equal to the water content of the first liquid, if the second liquid in the drying processing tank 22 is used for a long period of time, there is a concern that the dry state of the glass substrate 10 will deteriorate. The water content of the second liquid is more than 1.0 wt%, for example.

[0039] When the glass substrate 10 contains alkali metal components such as

Li₂O, Na₂O, and K₂O, the cleaning processing preferably includes water treatment in which the glass substrate 10 is immersed in water having a temperature of 40°C or more and 50° or less so as to clean the surfaces. For example, water in the pure water cleaning tank 14 or the pure water cleaning tank 18 that is shown in FIG. 1 is preferably warm water having a temperature of 40°C or more and 50°C or less. The alkali metal components on the surfaces of the glass substrate 10 are easily dissolved in water due to use of warm water having a temperature of 40°C or more and 50°C or less, and bloom, which has been a conventional problem, can be easily prevented. Thus, even if the second liquid in the drying processing tank 22 contains water, bloom is unlikely to appear.

[0040] Also, when the cleaning processing includes processing with the first liquid in the IPA cleaning tank 20 and water treatment (processes in the pure water cleaning tank 14 or the pure water cleaning tank 18) in which the glass substrate 10 is immersed in water having a temperature of 40°C or more and 50°C or less so as to clean the surfaces of the glass substrate 10, it is preferable that the glass substrate 10 undergoes processing in the order of the water treatment, the cleaning processing with the first liquid, and the drying processing. As a result of performing the processes in such an order, after the alkali metal components on the surfaces of the glass substrate 10 are dissolved in water through water treatment, the glass substrate 10 undergoes the cleaning processing with the second liquid containing IPA, and thus bloom is unlikely to appear and cleaning stains are unlikely to appear on the glass substrate 10.

[0041] Experimental Example 1

In order to check the effect of the present embodiment, the water content of the first liquid in the IPA cleaning tank 20 was changed in various ways and cleaning stains were observed. Note that in Experimental Example 1 and Experimental Examples 2 and 4 that will be described later, glass substrates having the following glass composition shown in mol% in terms of

oxides were used.

SiO₂: 66.2%,

Al₂O₃: 12.0%,

Li₂O: 11.1%,

5 Na₂O: 5.5%,

K₂O: 3.4%,

ZrO₂: 1.8%.

[0042] The cleaning stains were observed visually, and a three-level evaluation was made in accordance with the frequency of cleaning stains. Level A means
 10 that no cleaning stains appeared at all on 100 glass substrates (acceptable level), Level B means that cleaning stains were found on one glass substrate in 100 glass substrates, but no cleaning stains were found on 99 glass substrates, which is allowable since the frequency of cleaning stains was extremely low (acceptable level), and Level C means that cleaning stains appeared on two or
 15 more glass substrates in 100 glass substrates, which is not allowable (unacceptable level).

Furthermore, the period of time until a drying failure batch appeared due to an increase in the water content in the drying processing tank 22 was evaluated. An increase in the water content in the drying processing tank 22
 20 is caused by water being taken from the IPA tank 20 to the drying processing tank 22. Specifically, processing in which the processing time for each tank in which the cleaning processing and the drying processing were performed was set to five minutes was performed on one batch of 100 glass substrates. The drying failure batch refers to a batch in which when the dry state of a surface of
 25 a glass substrate immediately after the drying processing is checked visually, a non-dry state occurs on two or more glass substrates in one batch of the 100 glass substrates.

The second liquid in the drying processing tank 22 was IPA and no water was added. That is, the water content of the second liquid was 0 wt%.

30 Table 1 below shows the results of evaluation of cleaning stains when

the water content in the first liquid was changed, and the time until the drying failure batch appeared.

[0043] [Table 1]

	Water content (wt%) of first liquid	Cleaning stains	Period of time until drying failure batch appeared
Ex. 1	0.0	C	24 hours or more
Ex. 2	2.0	C	24 hours or more
Ex. 3	3.0	B	24 hours or more
Ex. 4	5.0	A	24 hours or more
Ex. 5	10.0	A	24 hours or more
Ex. 6	20.0	A	24 hours or more
Ex. 7	30.0	A	24 hours or more
Ex. 8	35.0	A	12 hours
Ex. 9	40.0	A	11 hours
Ex. 10	45.0	A	7 hours
Ex. 11	50.0	A	6 hours

5 [0044] According to Table 1, the appearance of cleaning stains can be suppressed by setting the water content of the first liquid in the IPA cleaning tank 20 to 3.0 wt% or more. Also, as shown in Example 8, even if the water content of the first liquid was 35.0 wt% or the water content was 40 to 50 wt%, it was confirmed that no cleaning stains appeared.

10 Furthermore, as Example 12, the cleaning processing and the drying processing were performed on the glass substrates under conditions similar to those in Example 3 except that water in an amount of 2.0 wt% was added to the second liquid in the drying processing tank 22. The main surfaces of the 100 glass substrates that were obtained in Example 3 and Example 12 were
 15 observed in detail using a laser surface inspection device, and the number of glass substrates on which cleaning stains that were too small to be observed visually appeared on outer circumferential edge portions was counted. As a result, 3 substrates in the 100 substrates had cleaning stains in Example 3, whereas one substrate had cleaning stains in Example 12. According to this,
 20 an improvement in cleaning stains was found due to the second liquid in the drying processing tank 22 containing water.

Also, as Example 10 and Example 11, if the water content of the first

liquid was set to 45.0 wt% or 50.0 wt%, the period of time until the drying failure batch appeared shortened drastically. With the water content of the first liquid in Examples 10 and 11, the amount of water taken into the drying processing tank 22 increases at the time of mass production, and if the
5 continuous production amount increases, the period of time until the drying failure batch appeared shortens drastically. Thus, the frequency of instances of exchange of the second liquid in the drying processing tank 22 increases, and there is a concern that the productivity will decrease. From this respect, the upper limit of the water content of the first liquid is 40.0 wt%, and preferably
10 35.0 wt%.

[0045] Experimental Example 2

Furthermore, in order to check the effect of the present embodiment, the water content of the second liquid in the drying processing tank 22 was changed in various ways and cleaning stains were observed. At that time, the
15 water content of the first liquid was fixed at 0.0 wt%.

The cleaning stains were observed visually, and a three level-evaluation was made in accordance with the frequency of cleaning stains. Level A means that no cleaning stains appeared at all on 100 glass substrates (acceptable level), Level B means that cleaning stains were found on one glass substrate in
20 100 glass substrates, but no cleaning stains were found on 99 glass substrates, which is allowable since the frequency of cleaning stains was extremely low (acceptable level), and Level C means that cleaning stains appeared on two or more glass substrates in 100 glass substrates, which is not allowable (unacceptable level).

Also, the dry states of the surfaces of the glass substrates immediately after the drying processing were checked visually. The dry states were evaluated at three levels in accordance with the frequency of glass substrates in non-dry states. Level A means that all of the 100 glass substrates were dried, Level B means that one substrate in 100 glass substrates was not sufficiently
30 dried but 99 glass substrates were dried, and the frequency of glass substrates

in the non-dry state was extremely low, and Level C means that two or more glass substrates in 100 glass substrates were in the non-dry state. Note that non-dry or the non-dry state refers to the state immediately before a glass substrate is completely dried in the vicinity of a portion being observed at which the glass substrate and a holding jig that holds the glass substrate are in contact with each other. Note that these non-dry states were all resolved ultimately.

Table 2 below shows the results of evaluation of cleaning stains when the water content in the second liquid was changed.

[0046] [Table 2]

	Water content (wt%) of second liquid	Cleaning stains	Dry state
Ex. 13	0.0	C	A
Ex. 14	0.5	C	A
Ex. 15	1.0	C	A
Ex. 16	1.1	B	A
Ex. 17	1.3	A	A
Ex. 18	2.8	A	A
Ex. 19	3.0	A	B
Ex. 20	4.0	A	B
Ex. 21	5.0	A	B
Ex. 22	6.0	A	C

[0047] According to the result of Table 2, it was found that setting the water content of the second liquid to more than 1.0 wt%, and preferably 1.1 wt% or more made it possible to suppress the appearance of cleaning stains. In order to reliably dry the surfaces of the glass substrate with the drying processing in the drying processing tank 22, it was found that the water content was preferably set to 5.0 wt% or less and less than 3.0 wt%, and more specifically, 2.8 wt% or less. Accordingly, the effects of the present embodiment are clear.

[0048] Experimental Example 3

The total content of the alkali metal components was changed in various ways, with a focus on the alkali metal components such as Li_2O , Na_2O , and K_2O , in the glass composition in the glass substrate, and cleaning stains and bloom were observed visually and evaluated. If the content of the alkali

metal components was increased or reduced, the content of components other than SiO₂ was kept constant, and the content of SiO₂ was increased or reduced. The evaluation of the cleaning stains and bloom was made in Levels A to C that were the same as those in Experiment Example 1. Table 3 shows the evaluation results.

[0049] [Table 3]

	Content of alkali metal components (mol%)	Cleaning stains	Bloom
Ex. 23	26.0	A	C
Ex. 24	24.0	A	C
Ex. 25	22.0	A	B
Ex. 26	20.0	A	A
Ex. 27	18.0	A	A

[0050] According to the result of Table 3, the content of the alkali metal components included in the glass substrate is preferably 22.0 mol% or less, and more preferably 20.0 mol% or less from the viewpoint of prevention of bloom in addition to the cleaning stains.

[0051] Experimental Example 4

The water content in the second liquid in the drying processing tank 22 was further studied in detail, and the cleaning stains were observed. At that time, if the water content of the first liquid was fixed at 3.0 wt% and the water content of the second liquid was changed in various ways, all cleaning stains were at the acceptable level in the visual observation, but at that time, the cleaning stains were observed in detail with a laser surface inspection device. The cleaning stains were evaluated in detail by checking the number of glass substrates on which small cleaning stains (cleaning stains appeared in the vicinity of the outer circumference of a glass substrate) that were not observed visually appeared, in 100 glass substrates. Table 4 below shows the evaluation results.

[0052] [Table 4]

	Water content of second liquid (wt%)	Number of glass substrates with small cleaning stains observed with laser surface inspection device
Ex. 28	0.0	3 or more
Ex. 29	0.5	3 or more
Ex. 30	1.0	2
Ex. 31	1.5	1 or less
Ex. 32	2.0	1 or less
Ex. 33	4.0	1 or less
Ex. 34	6.0	1 or less

[0053] According to the results of Table 4, it is found that even if the water content of the first liquid was set to 3.0 wt% or more, the number of glass substrates on which small cleaning stains appeared was reduced to one or less in the 100 glass substrates by setting the water content of the second liquid to more than 1.0 wt%, and preferably 1.5 wt% or more.

[0054] As described above, although a method for manufacturing a magnetic-disk glass substrate of the present invention has been described in detail, the present invention is not limited to the above-described embodiment and working examples, and it will be appreciated that various improvements and modifications can be made without departing from the gist of the present invention.

[Descriptions of Reference Numerals]

- [0055] 10 Glass substrate
- 12 Alkaline cleaning tank
- 14, 18 Pure water cleaning tank
- 16 Neutral detergent cleaning tank
- 20 IPA cleaning tank
- 22 Drying processing tank

CLAIMS

1. A method for manufacturing a magnetic-disk glass substrate, comprising:

5 cleaning processing for cleaning a surface of the glass substrate; and
drying processing for drying the surface after the cleaning processing,
wherein the cleaning processing includes first liquid treatment in which
the glass substrate is immersed in a first liquid containing water and a water-
soluble solvent having a boiling point lower than that of water;

10 the drying processing is processing in which the glass substrate is
disposed in vapor of a second liquid containing water and the water-soluble
solvent having a boiling point lower than that of water, at least a portion of
droplets on the glass substrate are allowed to drip from the glass substrate while
droplets are allowed to form on the surface of the glass substrate, and the glass
15 substrate is dried;

the first liquid contains the water-soluble solvent as a main component,
and water in an amount of 3.0 wt% or more; and

a water content of the second liquid is lower than a water content of the
first liquid.

20 2. The method for manufacturing a magnetic-disk glass substrate
according to claim 1, wherein

the water content of the second liquid is more than 1.0 wt%.

25 3. A method for manufacturing a magnetic-disk glass substrate,
comprising:

cleaning processing for cleaning a surface of the glass substrate; and
drying processing for drying the surface after the cleaning processing,
wherein the cleaning processing includes first liquid treatment in which
30 the glass substrate is immersed in a first liquid containing water and a water-

soluble solvent having a boiling point lower than that of water;

the drying processing includes disposing the glass substrate in vapor of a second liquid containing water and the water-soluble solvent having a boiling point lower than that of water, and allowing a portion of droplets on the glass substrate to drip from the glass substrate while allowing droplets to form on the surface of the glass substrate;

a water content of the first liquid is higher than a water content of the second liquid; and

the second liquid contains the water-soluble solvent as a main component, and the water in an amount of more than 1.0 wt%.

4. The method for manufacturing a magnetic-disk glass substrate according to any one of claims 1 to 3, wherein

the glass substrate contains an alkali metal component, and

the cleaning processing includes water treatment in which the surface is cleaned by immersing the glass substrate in water having a temperature of 40°C or more and 50°C or less.

5. The method for manufacturing a magnetic-disk glass substrate according to claim 4, wherein

the glass substrate undergoes processing in the order of the water treatment, the first liquid treatment, and the drying processing.

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

the water-soluble solvent is isopropyl alcohol.

7. The method for manufacturing a magnetic-disk glass substrate according to any one of claims 1 to 6, wherein

a total content of alkali metal components in the glass substrate is 22.0

mol% or less in terms of oxides.

8. A method for manufacturing a magnetic-disk, comprising:

5 manufacturing a magnetic-disk glass substrate according to any one of claims 1 to 7; and

stacking a magnetic layer on a surface of the magnetic-disk glass substrate.

9. A cleaning apparatus for a glass substrate, comprising:

10 an cleaning tank storing a first liquid in which the glass substrate is immersed, the first liquid containing water and a water-soluble solvent having a boiling point lower than that of water; and

15 a dry processing tank storing a second liquid containing water and the water-soluble solvent having a boiling point lower than that of water, and vapor of the second liquid in a space above the second liquid;

wherein the space of the dry processing tank is configured to allow at least a portion of droplets on the glass substrate to drip from the glass substrate subjected to immersion in the first liquid while allow droplets to form on the surface of the glass substrate by disposing the glass substrate in the vapor of the second liquid for drying the glass substrate,

20 the first liquid contains the water-soluble solvent as a main component, and water in an amount of 3.0 wt% or more; and

a water content of the second liquid is lower than a water content of the first liquid.

25

10. The cleaning apparatus according to claim 9, wherein the water content of the second liquid is more than 1.0 wt%.

11. A cleaning apparatus for a glass substrate, comprising:

30 an cleaning tank storing a first liquid in which the glass substrate is

immersed, the first liquid containing water and a water-soluble solvent having a boiling point lower than that of water; and

a dry processing tank storing a second liquid containing water and the water-soluble solvent having a boiling point lower than that of water, and vapor
5 of the second liquid in a space above the second liquid;

wherein the space of the dry processing tank is configured to allow at least a portion of droplets on the glass substrate to drip from the glass substrate subjected to immersion in the first liquid while allow droplets to form on the surface of the glass substrate by disposing the glass substrate in the vapor of
10 the second liquid for drying the glass substrate,

a water content of the first liquid is higher than a water content of the second liquid, and

the second liquid contains the water-soluble solvent as a main component, and the water in an amount of more than 1.0 wt%.

15

12. The cleaning apparatus according to any one of claims 9 to 11, further comprising a water cleaning tank storing water in which the glass substrate is immersed, the water having a temperature of 40°C or more and 50°C or less.

20

13. The cleaning apparatus according to claim 12, wherein

cleaning processing in the cleaning tank storing the first liquid is performed to the glass substrate subjected to immersion in the water of the water cleaning tank.

25

14. The cleaning apparatus according to any one of claims 9 to 13, wherein the water-soluble solvent is isopropyl alcohol.

15. The cleaning apparatus according to any one of claims 9 to 14, wherein the glass substrate is a magnetic-disk glass substrate.

30