Description

METHOD FOR MANUFACTURING GLASS SUBSTRATE FOR MAGNETIC INFORMATION-RECORDING MEDIUM

Technical Field

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

Background Art

[0002] A magnetic disk is a typical information recording medium having a recording layer for recording information by using magnetic, optical, and magneto-optical properties. Glass substrates and aluminum alloy substrates plated with a nickel-phosphorus alloy are known as substrates for such magnetic disks. Glass substrates have been mainly used in notebook personal computers due to its high surface hardness and resistance to scratching. The magnetic disk substrate is placed on a hard disk drive, and magnetic information is recorded or reproduced while rotating the disk at a high rate in a state in which a magnetic head floats at a predetermined height above the substrate surface. In order to increase the recording density, it is necessary to reduce further the floating amount of the magnetic head. In this case, where very fine foreign material is present on the magnetic disk, the head and the disk collide. Thus, a phenomenon called head crash occurs and the hard disk cannot be used. Further, since the floating stability of the head is affected even when the head crash does not occur, the glide characteristics (indicates how stably the head floats above the magnetic disk) is degraded.

[0003] Meanwhile, methods for preparing glass base plates include a method by which molten glass is caused to flow on a molten metal and a sheet-shaped glass base plate is produced and then cut to the necessary size, and a method by which the molten glass is press molded as is to the predetermined size. In recent years, the method of cutting from the sheet-shaped glass plate is mainly used because it enables large-volume inexpensive production. In this case, when a sheet material is cut into glass plates, cracks occur from the cut lines.

[0004] Where cracks are present, alkali components present in the glass substrates are leached out from the crack zone and the recording surface is contaminated. As a result, the leached-out components and the head sometimes collide, thereby causing a head crash. Hard disks have recently found application for car navigation systems installed on vehicles, and therefore such hard disks require high heat resistance. When hard disks are used at a high temperature, the elution of alkali components is especially significant. As a result, the occurrence of head crash caused by the eluted components becomes a problem and the presence of even small cracks cannot be allowed.

[0005] A manufacturing method in which a cut line is introduced obliquely and the glass base plate is cut along the cut line has been suggested as a method for reducing the number of cracks (see, for example, Patent Document 1).

[0006] However, when the glass substrate manufactured by such a method is placed on a hard disk, the glide characteristics is also degraded, heat is generated due to the contact of the magnetic disk with the recording-reproducing element unit of the head, and such heat generation causes a transient phenomenon called thermal asperity during which recording and reproduction are impossible.

[0007] In particular, in recent years, in the hard disks in which the gap between the disk surface and the head recording-reproduction element unit having a DFH mechanism is close to 2 nm or less, the phenomenon tends to occur due to tiny surface defects, surface roughness,

and waviness, which conventionally caused no problem. The DFH mechanism as referred to herein is the dynamic flying height control technique (DFH control technique) that reduces the distance between the information recording medium and the so-called ABS surface (Air Bearing Surface) by bringing only the head element performing the recording-reproduction operation in the magnetic head close to the information recording medium when the information is written to or read from the information recording medium.

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Summary of the Invention

[0009] It is an object of the present invention to provide a method for manufacturing a glass substrate for magnetic information-recording medium whereby the number of cracks on the surface of a glass base plate can be reduced and the resulting glass substrate exhibits an excellent glide characteristics when mounted on a hard disk.

[0010] The method for manufacturing a glass substrate for a magnetic information-recording medium in accordance with the present invention includes: a cutting step of introducing a cut line into one surface of a glass base plate and cutting the glass base plate along this cut line; and a lapping step of lapping a surface of the glass base plate by using upper and lower lap plates in which fixed abrasive grains including diamond grains are provided on lapping surfaces, wherein in the lapping step, the surface with the cut line introduced thereinto is disposed on the upper lap plate side, and the surface into which the cut line has not been introduced is disposed on the lower lap plate side.

[0011] The above-described and other objects, features, and merits of the present invention will become apparent from the following detailed description and the appended drawings.

Brief Description of the Drawings

[0012] [Fig. 1] Fig. 1 is a top view illustrating a glass substrate for a magnetic information-recording medium manufactured by the method for manufacturing a glass substrate for a magnetic information-recording medium of the present embodiment.

[Fig. 2] Fig. 2 is a schematic cross-sectional view illustrating the cutting step of cutting a glass base plate in the method for manufacturing a glass substrate for a magnetic information-recording medium of the present embodiment.

[Fig. 3] Fig. 3 is a schematic cross-sectional view illustrating an example of a lapping device used in the lapping step in the method for manufacturing a glass substrate for a magnetic information-recording medium of the present embodiment.

[Fig. 4] Fig. 4 is a perspective view with a partial cross section illustrating a magnetic disk which is an example of a magnetic recording medium using the glass substrates for a magnetic information-recording medium manufactured by the method for manufacturing a glass substrate for a magnetic information-recording medium of the present embodiment.

Description of embodiments

[0013]The method for manufacturing a glass substrate for a magnetic information-recording medium according to the present embodiment includes: a cutting step of introducing a cut line into one surface of a glass base plate and cutting the glass base plate along this cut line; and a lapping step of lapping a surface of the glass base plate by using upper and lower lap plates in which fixed abrasive grains including diamond grains are provided on lapping surfaces, wherein in the lapping step, the surface with the cut line introduced thereinto is disposed on the upper lap plate side, and the surface into which the cut line has not been introduced is disposed on the lower lap plate side.

[0014] The method for manufacturing a glass substrate for a magnetic information-recording medium according to the present embodiment is not particularly limited, provided that it

includes the cutting step and the lapping step. More specifically, operations other than the disk processing step including the cutting step of introducing a cut line into a glass base material sheet manufactured by a float method and cutting, and the step of arranging the surface into which the cut line has been introduced, disposing this surface on the top lap plate of a lapping device, disposing the surface into which the cut line has not been introduced on the lower lap plate, and lapping the glass substrates are not particularly limited and may be performed by the conventional manufacturing method.

[0015] A glass substrate for a magnetic information-recording medium can be manufactured, for example, by a method including a disk processing step, a lapping step, a rough polishing step (primary polishing step), a washing step, a chemical strengthening step, a fine polishing step (secondary polishing step), and a final washing step. The steps may be performed in the order of description, or the order of the chemical strengthening step and fine polishing step (secondary polishing step) can be reversed. Methods including other steps may be also used. For example, an end surface polishing step may be performed between the lapping step and the rough polishing step (primary polishing step).

[0016] The disk processing step in the manufacturing method in accordance with the present invention is explained below in greater detail.

[0017] <Disk Processing Step>

In the disk processing step, a disk-shaped glass base plate 10 in which a through hole 10a is formed in the central section so that the inner circumference and outer circumference are concentric circles, as shown in Fig. 1, is processed from a glass base plate molded into a plate-like shape from a glass base material of a predetermined composition. More specifically, the processing is performed, for example, in the following manner.

[0018] Fig. 2 is a cross-sectional view illustrating the step of cutting a disk-shaped glass substrate in accordance with the present invention.

[0019] The disk processing step includes a cutting step of introducing cut lines into one surface of a glass base material formed in a plate-like shape on a molten metal and then cutting along the cut lines. In the cutting step, the cut lines are formed in the surface of the glass base plate where the glass base material has been in contact with the molten metal and then a disk-shaped glass base plate is cut out by expanding the cut lines in the thickness direction of the glass base plate.

[0020] Fig. 2A is a cross-sectional view of the plate-shaped glass base material 1.

[0021] The plate-shaped glass base material is manufactured by a float method. The float method is realized, for example, by allowing a liquid melt obtained by melting the glass base material to flow on molten tin and solidifying the molten glass thereon. In the obtained glass base plate, one surface is the free surface of the glass (referred to hereinbelow as "free surface"), and the other surface (referred to hereinbelow as "contact surface") is the interface of glass and tin and, therefore, has high smoothness. The thickness thereof is, for example, 0.95 mm. The surface roughness, for example, Ra, of the glass base plate or glass substrate can be measured by using a typical surface roughness measuring device.

[0022] Therefore, the glass base material has a surface that is in contact with the molten metal and the other surface. In the case of the glass base material 1 shown in Fig. 2A, the upper surface is a contact surface 1A, and the lower surface is a free surface 1B.

[0023] A cut line drawn along a curved line substantially forming the circumferential edge of the region that is to be the glass substrate for a magnetic disk is formed in the contact surface 1A of the glass base material 1. In the present embodiment, as shown in Fig. 2B, circular cut lines 2, 3 describing the outer circumference and inner circumference of the disk are formed by a glass cutter 4 in the contact surface 1A of the glass base material 1.

[0024] The cut lines 2, 3 on the outer circumference and inner circumference are formed in this case obliquely in the thickness direction of the glass plate. Further, in the present

embodiment, the cut lines 2, 3 are formed to be inclined outward from the contact surface 1A of the glass base material 1 toward the free surface 1B side. As shown in the cross-sectional view in Fig. 2B, the left and right cut lines 2 and cut lines 3 are formed to obtain the truncated cone configuration. Further, in the present embodiment, the cut lines 2, 3 are formed to be inclined outward from the contact surface 1A of the glass base material 1 toward the free surface 1B side, but such a configuration is not limiting. For example, in another possible method, the cut lines 2, 3 are formed to be inclined inward from the contact surface 1A of the glass base material 1 toward the free surface 1B side and so as to obtain an inversed truncated cone configuration of the left and right cut lines 2 and cut lines 3, as shown in Fig. 2B, and the inner portion bounded by the cut line is taken upward by expanding the cut lines.

[0025] Then, as shown in Fig. 2C, the cut lines 2, 3 formed in the contact surface 1A of the glass base material 1 are expanded toward the free surface 1B side. As a result, a state is assumed in which the inner region 10a bounded by the cut line 2 is separated from the glass base material 1. Further, a state is assumed in which the inner portion 10b bounded by the cut line 3 is separated from the region 10a bounded by the cut line 2.

[0026] Means for inducing a difference in thermal expansion in the glass base material 1, for example, a method of heating one side surface of the glass base material 1, can be advantageously used as means for expanding the cut lines 2, 3 formed in the contact surface 1A of the glass base material 1 toward the free surface 1B. Where the glass base material 1 is heated, a difference in thermal expansion occurs in the plate thickness direction of the glass base material 1 and the glass base material can be easily cut into the target disk shape.

[0027] Then, as shown in Fig. 2D, the inner regions 10a, 10b bounded by the cut line 2 are pushed out downward, and then the region 10b bounded by the cut line 3 is pushed out, thereby producing a disk-shaped glass base plate 10 having a round hole in the central section.

[0028] The surface roughness Ra of the glass base plate after the cutting step is preferably 5 nm or more and 50 nm or less, and the maximum-height roughness Rz is 20 nm or more and 100 nm or less. Where the surface roughens Ra or maximum-height roughness Rz of the glass base plate after the cutting step is too large, the lapping damage becomes large, and where the roughness is too small, the lapping step cannot be performed.

[0029] A chemical treatment step may be performed to obtain the abovementioned value of the surface roughness Ra after the cutting step. The chemical treatment step, as referred to herein, is a step of etching and roughening the glass surface by using a solution capable of dissolving the glass, such as hydrofluoric acid, thereby facilitating the processing.

[0030] The disk processing step in accordance with the present invention may include a step of polishing the corners (end surfaces) of the cut lines after the cutting step. Such end-surface polishing step makes it possible to reduce the number of cracks on the glass substrate generated by the cut lines.

[0031] In the disk processing step, the disk-shaped glass base plates are obtained, for example, with an outer diameter r1 of 2.5 inch (about 64 mm), 1.8 inch (about 46 mm), 1 inch (about 25 mm), and 0.8 inch (about 20 mm) and a thickness of 2 mm, 1 mm, or 0.63 mm. When the outer diameter r1 is 2.5 inch (about 64 mm), the processing is performed to an inner radius r2 of 0.8 inch (about 20 mm).

[0032] <Lapping Step>

In the lapping step, the glass base plate is processed to a predetermined thickness. More specifically, in this step, the two surfaces of the glass base plate are ground (lapped). Such processing makes it possible to adjust the parallelism, flatness, and thickness of the glass base plate and obtain the desired surface waviness.

[0033] The surface waviness, as referred to herein, is a three-dimensional surface shape formed on the surface of the glass base plate and configured by selecting the shape of a

wavelength band with a shape wavelength of 0.1 mm or more and 5 mm or less. The surface waviness can be determined by observing the predetermined region of the glass base plate under a microscope or the like.

[0034] OptiFLAT manufactured by Phase Shift Technology Inc. can be advantageously used as a surface waviness observation device.

[0035] In the present invention, the average height of surface waviness is represented by Wa. The average height (Wa) of surface waviness represents the arithmetic average roughness of the surface waviness shape. The maximum height of surface waviness in the present embodiment can be called PV. The maximum height (PV) of surface waviness, as referred to herein, is a value obtained by calculating the average plane of the surface waviness shape, and adding up the absolute value of the height of the highest peak above the average plane and the absolute value of the depth of the deepest valley below the average plate.

[0036] The lapping device used in the lapping step is not particularly limited, provided that it can be used to manufacture a glass substrate. For example, the lapping device 5 such as shown in Fig. 3 can be used. Fig. 3 is a schematic cross-sectional view illustrating an example of a lapping device used in the lapping step in the method for manufacturing a glass substrate for a magnetic information-recording medium of an embodiment of the present invention.

[0037] The lapping device 5, such as shown in Fig. 3, can perform lapping at both surfaces at the same time. The lapping device 5 is provided with a device main body unit 5a and a coolant supply unit 5b supplying a coolant, which is cooling liquid, to the device main body unit 5a.

[0038] The device main body unit 5a is provided with a disk-shaped upper lap plate 6 and a disk-shaped lower lap plate 7 which are disposed parallel to each other at a certain distance

from each other in the vertical direction. The disk-shaped upper lap plate 6 and the disk-shaped lower lap plate 7 rotate in the mutually opposite directions.

[0039] Fixed abrasive grains 8 including diamond grains are provided on the mutually opposing surfaces of the disk-shaped upper lap plate 6 and the disk-shaped lower lap plate 7 in order to ground the front and rear surfaces of the glass base plate 10. The fixed abrasive grains 8 including diamond grains that are used in the lapping step may be in the form of pellets obtained by bonding a plurality of diamond grains with a resin, or in the form of a sheet obtained by planarly bonding diamond grains to the upper lap plate 6 and the lower lap plate 7 with a resin or by electrodeposition.

[0040] A carrier may be sandwiched between the fixed abrasive grains 8 and the lap plates 6, 7. The carrier revolves in the same direction as the lower lap plate 7 about the rotation center of the lap plates 6, 7 while rotating in a state of holding a plurality of glass base plates 10. The disk-shaped upper lap plate 6 and the disk-shaped lower lap plate 7 can be operated by separate drives. In the lapping device 5 operated in such a manner, the lapping treatment of the glass base plate 10 can be performed by supplying the coolant 11 between the fixed abrasive grains 8 and the glass base plate 10 and between the fixed abrasive grains 8 and the glass base plate 10.

[0041] The coolant supply unit 5b is provided with a container containing the coolant 11 and a pump 9. Thus, the coolant 11 located inside the container is supplied into the lap plates 6, 7 and circulated by the pump 9. The chips that appear on the lapping surfaces of the upper and lower lap plates 6, 7 during the circulation are removed from the lapping surfaces. Thus, the chips are filtered by the filter provided inside the lower lap plate 7 when the coolant 11 is circulated, and the filtered chips are retained in the filter.

[0042] More specifically, the lapping step should be performed such that the entire surface of the glass base plate has a substantially uniform surface roughness. However, the

comprehensive research conducted by the inventors made it clear that the typical lapping machine for glass base plates having upper and lower lap plates demonstrates different lapping performance at the upper and lower lap plates. Thus, because of the difference in acting pressure caused by gravity, the lapping processing performance of the upper lap plate is somewhat superior to that of the lower lap plate.

[0043] More specifically, the ratio between the processing rate of the upper lap plate and the processing rate of the lower lap plate is preferably 1 : 0.8 to 1 : 0.98, more preferably 1 : 0.9 to 1 : 0.95.

[0044] The processing rate is a value obtained by dividing the processing allowance by the processing time. The deviation from the processing rate degrades the processing balance of the glass substrate.

[0045] The inventors have also noticed that the number of cracks in the surface where the cut lines have been formed in the disk processing step is larger than that in the surface having no cut lines. This is because the cut lines become the crack initiation points in the step of cutting the glass base material, and a large number of cracks propagate from the initiation points to the surrounding zones.

[0046] Therefore, where a plurality of glass base plates fabricated in the disk processing step are randomly arranged, regardless of the front-rear surface orientation, and directly lapped with the upper and lower lap plates that have different actual pressures in the lapping machine, as in the lapping step of the conventional method for manufacturing a glass substrate for a magnetic information-recording medium, a large number of glass substrates with a large number of cracks in each glass base plate are produced. Accordingly, when a plurality of glass base plates is ground by lapping only the surface with the cut lines that create a large number of cracks with the upper lap plate which has a high actual pressure, that is, a high processing rate, it is possible to produce reliably glass substrates with a small

number of cracks. As a result, when the magnetic disk using the glass substrate for a magnetic information-recording medium that has been subjected to the lapping step of the manufacturing method in accordance with the present invention is mounted on a hard disk, an excellent glide characteristics is obtained due to a small number of cracks.

[0047] Further, when the cracks are removed in a polishing step, pits or waviness sometimes remain because the processing is performed along the cracked zones, and those pits and waviness should be removed in the lapping step. In particular, since the cracks appear close to the end surface (portions into which cut lines are introduced) where the processing pressure is difficult to apply in the polishing step, the cracks are difficult to remove by polishing.

[0048] Furthermore, since the actual pressure applied to the substrate processed by the upper lap plate is constant when compared with that at the lower lap plate (i.e., the actual pressure is large), the cracks can be efficiently removed. This is because the lapping step is performed using the lapping liquid, and the lapping liquid is concentrated on the lower lap plate side under gravity. In the processing, the lapping liquid is circulated at all times while the glass sludge (glass chips) is removed in the filter. For this reason, the lapping liquid from which the sludge has been removed flows at the upper lap plate at all times, whereas the sludge easily remains at the lower lap plate side. The sludge makes it difficult to remove the cracks (the sludge can even cause the cracks to grow), and the cracks remain in the substrates that are the final products.

[0049] By efficiently removing the cracks at the upper lap plate side, it is possible to manufacture crack-free glass substrate and thus obtain a hard disk with an excellent glide characteristics.

[0050] In this case, for example, when the arithmetic average roughness Ra of the glass base plate is measured in a plurality of locations, it is preferred that the difference between the smallest value and largest value of the obtained Ra be about 0.01 μm to 0.4 μm.

[0051] Where the lapping process is implemented, the polishing in the below-described rough polishing process can be performed with high efficiency. Further, the surface roughness Ra of the glass base plate used in the polishing step implemented in the lapping process is preferably equal to or less than 0.5 μm, more preferably equal to or less than 0.3 μm. Where the surface roughness Ra is greater than 0.5 μm, large waviness can remain even after the subsequent polishing step. The maximum-height roughness Rz is preferably equal to or less than 3 μm. In such a case, the polishing step is facilitated.

[0052] The processing allowance for the glass base plate in the lapping step is preferably 50 μm or more and 300 μm or less, more preferably 100 μm or more and 200 μm or less. Where the processing allowance is less than 50 μm, the cracks originating at the surface where the cut lines have been introduced can remain, and where the allowance is greater than 300 μm, the processing time is extended and the efficiency of the manufacturing method is thus degraded.

[0053] The allowance for lapping at both surfaces of the glass base plate in the lapping step is equal to or greater than 50 μm, more preferably equal to or greater than 100 μm. Where the allowance is less than 50 μm, the cracks originating at the surface where the cut lines have been introduced can remain.

[0054] Further, the lapping step may be performed once or two or more times. When the lapping step is performed twice, in the lapping step of the first cycle (first lapping step), the parallelism, flatness, and thickness of the glass base plate are preliminary adjusted, and in the lapping step of the second cycle (second lapping step), the parallelism, flatness, and thickness of the glass base plate are finely adjusted.

[0055] <Rough Polishing Step>

In the rough polishing step (primary polishing step), the principal surface of the glass base plate is polished with a polishing slurry including cerium oxide with the object of removing scratches and strains remaining after the above-described lapping step. The rough polishing is implemented by using the following polishing method.

[0056] A polishing device for use in the rough polishing step is not particularly limited, provided it can be used for manufacturing a glass substrate.

[0057] The surface polished in the rough polishing step is a principal surface and/or an end surface. The principal end surface, as referred to herein, is a surface parallel to the surface direction of the glass base plate. The end surface, as referred to herein, is a surface constituted by an inner circumferential end surface and an outer circumferential end surface. The inner circumferential end surface is the surface perpendicular to the surface direction of the glass base plate and the surface inclined with respect to the surface direction of the glass base plate, those surfaces being on the inner circumferential side. The outer circumferential end surface is the surface perpendicular to the surface direction of the glass base plate and the surface inclined with respect to the surface direction of the glass base plate, those surfaces being on the outer circumferential side.

[0058] The polishing agent used in the polishing step in accordance with the present invention includes cerium oxide as the main component. The content ratio of cerium oxide is preferably 3 mass% to 15 mass% with respect to the entire amount of the polishing slurry. Where the content ratio of cerium oxide is within this range, it is possible to manufacture a glass substrate for a magnetic information-recording medium with better smoothness.

[0059] The polishing slurry, as referred to herein, is a liquid in a state in which the polishing agent, dispersant, and the like are dispersed in water, that is, a slurry liquid. In a state in which the polishing agent is dispersed in water, even if an alkaline earth metal is contained in

water, the alkaline earth metal is dissolved and, therefore, the alkaline earth metal is unlikely to adhere to the surface of the glass base plate. By contrast, the alkaline earth metal contained in the polishing agent easily adheres to the surface of the glass base plate. For this reason, the adhesion of alkaline earth metals to the polished glass base plate can be sufficiently inhibited by using a polishing agent with a small content of alkaline earth metals.

[0060] <Chemical Strengthening Step>

The chemical strengthening step in the manufacturing method in accordance with the present invention is not particularly limited and a well-known method can be used therefor. More specifically, for example, a step of immersing the glass base plate into a chemical strengthening treatment liquid can be used. As a result, a chemically strengthened layer can be formed at the surface of the glass base plate, for example, within a 5-μm region from the surface of the glass base plate. By forming the chemically strengthened layer, it is possible to improve impact resistance, vibration resistance, and heat resistance.

[0061] More specifically, the chemical strengthening step is performed by an ion exchange method in which the glass base plate is immersed in a heated chemical strengthening treatment liquid, whereby alkali metal ions such as lithium ion and sodium ion contained in the glass base plate are replaced with alkali metal ions of a larger ion radius, such as potassium ions. The strains occurring due to the difference in ion radius generate compressive stresses in the ion-exchanged region and the surface of the glass base plate is strengthened.

[0062] In the present embodiment, the strengthened layer is advantageously formed in the chemical strengthening step apparently as a result of using the glass composition such as described hereinabove for the glass base plate which is the raw material for the glass substrate. More specifically, this is apparently because from among Li_2O, Na_2O and K_2O, which are the alkali components of the glass base plate, the content ratio of Na_2O is high, and

sodium ions of the Na_2O are easily replaced by the potassium ions contained in the chemical strengthening liquid. Furthermore, since the polishing agent used in the polishing step, in this case, the rough polishing step, preceding the chemical strengthening step has the abovementioned composition, the amount of alkaline earth metals that have adhered to the surface of the glass base plate is small and the chemical strengthening is performed uniformly. Therefore, a glass substrate excelling in impact resistance can be manufactured by performing the fine polishing step with respect to the glass base plate that has been advantageously chemically strengthened, as in the present embodiment.

[0063] The chemical strengthening treatment liquid is not particularly limited, provided that it can be used in the chemical strengthening step in the method for manufacturing a glass substrate for a magnetic information-recording medium. More specifically, for example, a molten liquid including potassium ions and a molten liquid including potassium ions and sodium ions can be used.

[0064] Examples of such molten liquids include molten liquids obtained by melting potassium nitrate, sodium nitrate, potassium carbonate, and sodium carbonate. Among them, from the standpoint of obtaining the molten liquid with a low melting point and preventing the glass base plate from deformation, it is preferred that a combination of the molten liquid obtained by melting potassium nitrate and the molten liquid obtained by melting sodium nitrate be used. In this case, it is preferred that the molten liquid obtained by melting potassium nitrate and the molten liquid obtained by melting sodium nitrate be mixed in substantially equal amounts.

[0065] <Fine Polishing Step (Secondary Polishing Step)>

The fine polishing step is mirror-surface polishing treatment in which the flat and smooth principal surface obtained in the rough polishing step is held and finished, for example, to a smooth mirror surface with a maximum-height roughness (Rz) of the principal

surface equal to or less than amount 6 nm. This fine polishing step is implemented, for example, by using a polishing device same as that used in the rough polishing step and replacing the hard polishing pad with a soft polishing pad. The surface polished in the precise polishing step is the principal surface same as the surface polished in the rough polishing step.

[0066] A polishing agent that has polishing ability lower than that of the polishing agent used in the rough polishing step, but causes fewer scratches is used in the fine polishing step. More specifically, for example, a polishing agent including silica abrasive grains (colloidal silica) that are smaller in diameter than the polishing agent used in the rough polishing step can be used. The average particle diameter of the silica abrasive grains is preferably about 20 nm. The polishing slurry liquid including the polishing agent is supplied to the glass base plate, the polishing pad and the glass base plate are caused to vibrate relative to each other, and the surface of the glass base plate is mirror polished.

[0067] <Glass Base Plate Composition>

Each component of the glass base plate is described below in greater detail.

[0068] SiO_2, Al_2O_3, and B_2O_3 are skeleton components of the glass base plate. Li_2O, Na_2O, and K_2O are alkali components of the glass base plate. MgO, CaO, BaO, SrO, and ZnO are alkaline earth components of the glass base plate.

[0069] The skeleton components of the glass base plate are described below.

[0070] As mentioned hereinabove, SiO_2 at 58 mass% to 70 mass%, Al_2O_3 at 12 mass% to 18 mass%, and B_2O_3 at 0 mass% to 3 mass% (including 0) are used as the skeleton components of the glass base plate used in the present embodiment, the total content ratio thereof, that is, the total content ratio of SiO_2, Al_2O_3, and B_2O_3 being 72 mass% to 85 mass%.

[0071] SiO_2 is a component forming the glass skeleton (matrix). Where the content ratio of SiO_2 is too small, the glass structure becomes unstable, chemical durability thereof is

degraded, viscous properties during melting are degraded, and moldability is impeded. Where the content ratio of SiO_2 is too large, the melting ability is degraded, productivity is reduced, and sufficient rigidity cannot be obtained. Accordingly, it is preferred that the content ratio of SiO_2 be 58 mass% to 70 mass%.

[0072] Al_2O_3 is also a component forming the glass skeleton and contributes to the improved durability, strength, and surface hardness of the glass. Where the content ratio of Al_2O_3 is too small, the glass durability and strength are insufficient for a glass substrate for a magnetic information-recording medium. Where the content ratio of Al_2O_3 is too large, the devitrification tendency of the glass is strengthened and stable glass formation becomes difficult. Accordingly, it is preferred that the content ratio of Al_2O_3 be 12 mass% to 18 mass%.

[0073] B_2O_3 improves melting ability, increases productivity, stabilizes the glass structure by penetrating into the glass skeleton, and improves chemical durability of the glass. However, B_2O_3 tends to volatilize easily during melting, thereby making the glass composition unstable. Further, since the glass strength is reduced, the glass hardness is lowered, the glass substrate is easily scratched, the fracture toughness value is decreased, and the substrate tends to fracture easily. For those reasons, it is preferred that the content ratio of B_2O_3 be equal to or less than 3 mass%. Further, the glass composition containing no B_2O_3 can be also used. In the content ratio 0 mass% to 3 mass% of B_2O_3, which is mentioned hereinabove, 0 mass% means that a glass composition containing no B_2O_3 can be also used. The expression "0 mass%" in the glass composition of the description of the present application has the same meaning and indicates that the composition containing no component represented by this expression can be also used (same hereinbelow).

[0074] The total content ratio w of SiO_2, Al_2O_3, and B_2O_3 (FMO) is preferably 70 mass% to 85 mass%. Where such a condition is fulfilled, the glass structure is stabilized. Where the

total content ratio is too low, the glass structure tends to be unstable. Where the total content ratio is too large, the viscous characteristic during melting is degraded and the productivity tends to decrease.

[0075] The alkali components of the glass base plate are explained below.

[0076] As mentioned hereinabove, the alkali components of the glass base plate used in the present embodiment include Li_2O at 1 mass% to 8 mass%, Na_2O at 2 mass% to 13 mass%, and K_2O at 0.2 mass% to 2 mass%, the total amount thereof, that is, the total amount of Li_2O, Na_2O, and K_2O being 3.2 mass% to 23 mass%.

[0077] Among the alkali metal elements, Li_2O has a singular property and demonstrates the effect of greatly improving the Young's modulus by increasing the ion occupation ratio in the glass structure while acting to improve the dissolution ability of the glass. Where the content ratio of Li_2O is too small, the sufficient improvement of dissolution ability and sufficient increase in the Young's modulus cannot be attained. Where the content ratio of Li_2O is too large, it can become a trigger for extremely fine and thin reaction precipitates on the surface of the recording layer of the information-recording medium. Accordingly, the content ratio of Li_2O is preferably 1 mass% to 8 mass%.

[0078] Na_2O acts to decrease the melting temperature of glass and demonstrates the effect of increasing the linear thermal expansion coefficient. Further, it is apparently a component strongly affecting the effect of chemical strengthening in the chemical strengthening step. Thus, where the content ratio of Na_2O is too small, the melting temperature cannot be sufficiently lowered and the strength cannot be sufficiently increased in the chemical strengthening step. Further, where the content ratio of Na_2O is too large, the elution amount thereof increases and the recording layer can be adversely affected. Accordingly, the content ratio of Na_2O is preferably 2 mass% to 13 mass%. This content ratio is higher than that in the typical glass substrate.

[0079] K_2O acts to decrease the melting temperature of the glass and demonstrates the effect of increasing the linear thermal expansion coefficient. Where the content ratio of K_2O is too small, the melting temperature cannot be sufficiently decreased. Where the content ratio of K_2O is too large, the eluted amount thereof increases and can adversely affect the recording layer. In addition, a sufficient strength cannot be obtained in the chemical strengthening step. This is apparently because the strengthened layer is formed in the chemical strengthening step due to the replacement of sodium ions of Na_2O with potassium ions and this replacement is inhibited. Accordingly, the content ratio of K_2O is preferably 0.2 mass% to 2 mass%.

[0080] The total content ratio w (R_2O) of Li_2O, Na_2O, and K_2O is preferably 3.2 mass% to 23 mass%. Where this content ratio is too small, the melting point cannot be sufficiently decreased. Further, where this content ratio is small, the content ratio of Na_2O is also small and sufficient chemical strengthening cannot be demonstrated. Further, where this total content ratio is too large, the eluted amount increases and an adverse effect can be produced on the recording layer.

[0081] MgO, CaO, BaO, SrO, and ZnO, which are alkaline earth components of the glass base plate, demonstrate the effect of increasing the thermal expansion coefficient and rigidity and improving the melting ability. The total content ratio w of MgO, CaO, BaO, SrO, and ZnO (MgO + CaO + BaO + SrO + ZnO) is preferably 1 mass% to 10 mass%. Where this total content ratio is too small, the sufficient effect of increasing the rigidity and improving the melting ability cannot be obtained. Where the total content ratio is too large, the glass structure becomes unstable, melting productivity decreases, and chemical durability decreases.

[0082] The glass base plate may also include components other than those mentioned hereinabove. Specifically, for example, the glass base plate may include ZrO_2 and cerium oxide. The content ratio of ZrO_2 is preferably 0 mass% to 5 mass%. The content ratio of

cerium oxide is preferably 0 mass% to 2 mass%. Cerium oxide demonstrates the effect of inhibiting the occurrence of fine peaks and valleys when the glass base plate is polished using a polishing agent including cerium oxide.

[0083] The magnetic recording medium using the glass substrate for a magnetic information-recording medium manufactured by the method for manufacturing a glass substrate for a magnetic information-recording medium of the present embodiment is explained below.

[0084] Fig. 4 is a perspective view, with a partial cross section, illustrating a magnetic disk which is an example of a magnetic recording medium using the glass substrate for a magnetic information-recording medium manufactured by the method for manufacturing a glass substrate for a magnetic information-recording medium of the present embodiment. The magnetic disk D is provided with a magnetic film 102 formed on the principal surface of the round glass substrate 101 for a magnetic information-recording medium. A formation method based on the well-known usual means is used to form the magnetic film 102. Examples of suitable methods include a formation method (spin coating method) by which the magnetic film 102 is formed by spin coating a thermosetting resin having magnetic particles dispersed therein on the glass substrate 101 for a magnetic information-recording medium, a formation method (sputtering method) by which the magnetic film 102 is formed by sputtering on the glass substrate 101 for a magnetic information-recording medium, and a formation method (electroless plating method) by which the magnetic film 102 is formed by electroless plating on the glass substrate 101 for a magnetic information-recording medium.

[0085] The thickness of the magnetic film 102 is about 0.3 μm to about 1.2 μm when the spin coating method is used, about 0.04 μm to about 0.08 μm when the sputtering method is used, and about 0.05 μm to about 0.1 μm when the electroless plating method is used. From the standpoint of reducing the thickness and increasing the density, it is preferred that the film be formed by the sputtering method or by the electroless plating method.

[0086] A magnetic material to be used for the magnetic film 102 is not particularly limited and any well-known material can be used. For example, a Co-based alloy including Co with a high crystal anisotropy as a base component for obtaining a high coercive force and additionally including Ni or Cr with the object of adjusting the residual magnetic flux density is preferred as the magnetic material. More specifically, CoPt, CoCr, CoNi, CoNiCr, CoCrTa, CoPtCr, CoNiPt, CoNiCrPt, CoNiCrTa, CoCrPtTa, CoCrPtB, and CoCrPtSiO including Co as the main component can be used.

[0087] The magnetic film 102 may have a multilayer configuration (for example, CoPtCr/CrMo/CoPtCr, CoCrPtTa/CrMo/CoCrPtTa) in which magnetic layers are separated by non-magnetic films (for example, Cr, CrMo, CrV) in order to reduce noise. As the magnetic materials for the magnetic film 102, ferrites and iron-rare earth systems may be used in addition to the above-described magnetic materials, or granular structures in which magnetic particles such as Fe, CO, FeCo, and CoNiPt are dispersed in a non-magnetic film constituted by SiO_2 or BN may be used. Further, the inner-surface or vertical recording system may be used for recording on the magnetic film 102.

[0088] A lubricating agent may be thinly coated on the surface of the magnetic film 102 to improve the sliding of the magnetic head. For example, a perfluoropolyether (PFPE), which is a liquid lubricating agent, diluted with a solvent such as Freon can be used as the lubricating agent.

[0089] If necessary, the magnetic film 102 may be provided with a ground layer or a protective layer. The ground layer in the magnetic disk D can be selected, as appropriate, according to the magnetic film 102. At least one or more materials selected from nonmagnetic metals such as Cr, Mo, Ta, Ti, W, V, B, Al, and Ni can be used for the ground layer. For example, in the case of the magnetic film 102 including Co as the main component,

from the standpoint of improving a magnetic characteristic, it is preferred that Cr or a Cr alloy be used for the ground layer.

[0090] The ground layer is not necessary a single layer and may have a multilayer structure obtained by stacking same or different layers. The ground layer of a multilayer structure can be configured, for example, as Cr/Cr, Cr/CrMo, Cr/CrV, NiAl/Cr, NiAl/CrMo, NaAl/CrV. For example, a Cr layer, a Cr alloy layer, a carbon layer, a hydrogenated carbon layer, a zirconia layer, and a silica layer can be used as a protective layer preventing the magnetic film 102 from wear and corrosion. The protective layer can be formed together with the ground layer and the magnetic film 102 in a continuous manner in an inline sputtering device. The protective layer may have a single-layer configuration or may be constituted by a plurality of same or different layers.

[0091] Another protective layer may be formed on the abovementioned protective layer or instead thereof. For example, a SiO_2 layer may be formed, instead of the protective layer, on the Cr layer. Such SiO_2 layer can be formed on a Cr layer by diluting tetraalkoxysilane with an alcohol-based solvent, dispersing colloidal silica particles, coating, and firing.

[0092] Since the glass substrate 101 for a magnetic information-recording medium is formed from the above-described composition, the magnetic recording medium using the glass substrate 101 for a magnetic information-recording medium of the present embodiment can perform recording and reproduction of information with high reliability over a long period of time.

[0093] Explained above is the case in which the magnetic recording medium using the glass substrate 101 for a magnetic information-recording medium of the present embodiment is used for a magnetic recording medium, but such application is not limiting and the magnetic recording medium using the glass substrate 101 for a magnetic information-recording

medium of the present embodiment can be also used for magneto-optical disks or optical disks.

Examples

[0094] The present invention is explained in detail hereinbelow on the basis of examples thereof, but the present invention is not limited to those examples.

[0095] First, typical glass substrate, polishing agent, and polishing pad that are suitable for manufacturing the glass substrate for a magnetic information-recording medium were prepared. The compositions of the polishing agent and polishing pad include those that are typically used for manufacturing glass substrates for a magnetic information-recording medium.

[0096] Example 1

A glass substrate was used, a glass substrate was fabricated using a float method, and the disk processing step, lapping step, rough polishing step (primary polishing step), chemical strengthening step, fine polishing step (secondary polishing step), and final washing step were performed by the well-known methods.

[0097] However, in the lapping step, the surface of the glass base plate into which the cut lines were introduced was disposed on the upper lap plate side, and the surface into which the cut lines were not introduced was disposed on the lower lap plate side. The lapping in the lapping step was performed to obtain the allowance of 150 μm.

[0098] In this case, the processing in the lapping step was performed by using a sheet-shaped diamond tile (concentration degree 200, particle size 2 μm) in which diamond grains were bonded in a planar manner for the upper lap plate 6 and the lower lap plate 7. The surface roughness of the substrate after the lapping step was 0.21 μm. The surface roughness was measured with a contact roughness meter (manufactured by KLA Tencor Co.).

[0099] The principal surface roughness of the glass substrate after the rough polishing step, fine polishing step, and washing and drying step was 0.9 Å. By minimizing the principal surface roughness and smoothing the surface, it is possible to prevent ion components from eluting from the surface portions. The surface roughness Ra was measured by an atomic force microscope (AFM). AFM Dimension V manufactured by Veeco Instruments Inc. was used for the measurements. The measurements were performed with 256 scan lines of 10 μm × 10 μm.

[0100] Example 2

The manufacturing process was the same as in Example 1, except that the lapping was performed in the lapping step to obtain an allowance of 50 μm. The surface roughness Ra after the lapping step was 0.53 μm. The surface roughness of the final substrate was 1.0 Å.

[0101] Comparative Example 1

The manufacturing process was the same as in Example 1, except that the lapping in the lapping step was performed by disposing the glass base plate obtained in the disk processing step with random orientation of upper and lower surfaces. The surface roughness Ra after the lapping step was 0.43 μm and the surface roughness Ra of the final substrate was 1.1 Å.

[0102] Crack Evaluation Test

Since the cracks are extremely small, they cannot be detected with an optical inspection device. Accordingly, the amount of foreign matter on the surface of the glass substrate manufactured by the above-described manufacturing method was measured using OSA (Optical Surface Analyzer; manufactured by KLATENCOL Co., Candela 7120), the substrate was then heat treated and cooled, the surface was again observed with the OSA, and the variation in the amount of foreign matter was checked. The amount of foreign matter eluted from the cracks was thus determined. The smaller is the variation in the amount of

foreign matter, the fewer is the number of the cracks. The heat treatment was performed for 100 h under an environment with a temperature of 180°C and a humidity of 10% or less.

[0103] Glide characteristics Test

The manufactured glass substrate was placed on a hard sick and it was checked whether or not the substrate floats with stable glide. In the glide characteristics test, the hard disk was heat treated, the floatation height between the inspection head (head slider) and the surface of the magnetic recording medium was set to 4 nm, and the magnetic recording medium was determined to be defective when a signal caused by collision between the inspection head and a protrusion on the surface of the magnetic recording medium was outputted.

[0104] A total of 100 of the substrates manufactured by each method were evaluated. The evaluation criteria are described below.

[0105] A: The ratio of defective products is less than 5%.

B: Equal to or more than 5% and less than 10%.

C: Equal to or more than 10%.

[0106] The results obtained are shown in Table 1.

[0107] Table 1

	OSA count	OSA count (after heat treatment)	OSA count variation amount	Glide characteristics
Example 1	30	30	0	A
Example 2	32	41	9	B
Comparative Example 1	31	102	71	C

[0108] As demonstrated by the results in Table 1, in Comparative Example 1 in which a plurality of glass base plates used in the lapping step was arranged for lapping with a random orientation of upper and lower surfaces, the amount of foreign matter eluted from the cracks was larger, that is, a large number of cracks was initiated. Unsatisfactory results were also obtained in terms of the glide characteristics. Meanwhile, in Examples 1 and 2, since the amount of foreign matter eluted from the cracks was small, the number of creaks was found to be small. As a result, a good slide characteristic was obtained.

[0109] As described above, the present description discloses the features of various embodiments, and the main features can be summarized as follows.

[0110] The method for manufacturing a glass substrate for a magnetic information-recording medium in accordance with the present invention includes: a cutting step of introducing a cut line into one surface of a glass base plate and cutting the glass base plate along this cut line; and a lapping step of lapping a surface of the glass base plate by using upper and lower lap plates in which fixed abrasive grains including diamond grains are provided on lapping surfaces, wherein in the lapping step, the surface with the cut line introduced thereinto is

disposed on the upper lap plate side, and the surface into which the cut line has not been introduced is disposed on the lower lap plate side.

[0111] In the method for manufacturing a glass substrate for a magnetic information-recording medium, it is preferred that a ratio between a processing rate of the upper lap plate and a processing rate of the lower lap plate in the lapping step be 1 : 0.8 to 1 : 0.98.

[0112] In the method for manufacturing a glass substrate for a magnetic information-recording medium, it is preferred that a surface roughness Ra of a glass substrate after the lapping step be equal to or less than 0.5 μm and a maximum-height roughness Rz be equal to or less than 3 μm.

[0113] In the method for manufacturing a glass substrate for a magnetic information-recording medium, it is preferred that a processing allowance at each surface of the glass base plate in the lapping step be 50 μm or more and 300 μm or less.

[0114] This application claims priority to Japanese Patent Application No. 2010-291206 filed on December 27, 2010, and the contents thereof is incorporated herein.

[0115] The present invention is adequately and fully explained above by means of embodiments thereof, while referring to the appended drawings, in order to disclose the present invention, but it should be recognized that a person skilled in the art could easily change and/or modify the above-described embodiments. Therefore, the changed or modified embodiments implemented by a person skilled in the art can be interpreted to be included in the scope of the claims, as long as the changed or modified embodiments do not depart therefrom.

Industrial Applicability

[0116] The present invention can provide a method for manufacturing a glass substrate for a magnetic information-recording medium whereby the number of cracks on the surface of a

glass base plate can be reduced and the resulting glass substrate exhibits an excellent glide characteristics when mounted on a hard disk.

Claims

1. A method for manufacturing a glass substrate for a magnetic information-recording medium, comprising:

a cutting step of introducing a cut line into one surface of a glass base plate and cutting the glass base plate along this cut line; and

a lapping step of lapping a surface of the glass base plate by using upper and lower lap plates in which fixed abrasive grains including diamond grains are provided on lapping surfaces, wherein

in the lapping step, the surface with the cut line introduced thereinto is disposed on the upper lap plate side, and the surface into which the cut line has not been introduced is disposed on the lower lap plate side.

2. The method for manufacturing a glass substrate for a magnetic information-recording medium according to claim 1, wherein a ratio between a processing rate of the upper lap plate and a processing rate of the lower lap plate in the lapping step is 1 : 0.8 to 1 : 0.98.

3. The method for manufacturing a glass substrate for a magnetic information-recording medium according to claim 1 or 2, wherein a surface roughness Ra of a glass substrate after the lapping step is equal to or less 0.5 μm and a maximum-height roughness Rz is equal to or less than 3 μm.

4. The method for manufacturing a glass substrate for a magnetic information-recording medium according to any one of claims 1 to 3, wherein a processing allowance at each surface of the glass base plate in the lapping step is 50 μm or more and 300 μm or less.