GLASS SUBSTRATE FOR MAGNETIC RECORDING MEDIUM

FIELD OF THE INVENTION

[0001]

The present invention relates to a glass substrate for a magnetic recording medium.

BACKGROUND OF THE INVENTION

[0002]

Heretofore, aluminum alloy substrates have been employed as substrates for a magnetic recording medium used in magnetic disk recording apparatuses and the like. However, in recent years, with requirements for high density recording, glass substrates have become mainstream, which are hard as compared with aluminum alloy substrates and excel in flatness and smoothness.

[0003]

With the recent achievement of high recording density of a magnetic disk, a magnetic head has been configured to be passed to an end of a glass substrate in order to effectively utilize the area of a main surface of the glass substrate. In addition, in order to rapidly record and reproduce large-capacity information on and from a magnetic disk, it has been studied to increase the rotational speed of a magnetic disk.

[0004]

In the cases of passing a magnetic head up to a peripheral surface of a glass substrate and increasing the rotational speed of a magnetic disc, if there is irregularity in shape of an edge surface portion or a main surface of a glass substrate for a magnetic recording medium, the flying attitude of a magnetic head may be disrupted.

If the flying attitude of a magnetic head is disrupted, the magnetic head may be brought into contact with a magnetic disk. This may cause a failure. Thus, this is problematic. Accordingly, glass substrates for a magnetic recording medium have come to require high processing accuracy.

[0005]

A glass substrate for a magnetic recording medium is processed into a predetermined shape by polishing a peripheral surface (i.e., inner and outer peripheral surfaces) and a main surface thereof after undergoing a shape forming step and a chamfering step.

[0006]

A method for polishing a main surface of a glass substrate has the following steps. That is, first, a glass substrate is placed in a glass substrate retention hole provided in a carrier (i.e., a jig for polishing a main surface) capable of housing plural glass substrates. Then, the main surface of the glass substrate is polished by moving the carrier while supplying abrasive between the glass substrate and each of two polishing pads in a state of inserting, between the two polishing pads, the carrier in which the glass substrate is set (see, e.g., Patent Document 1).

[0007]

[Patent Document 1] JP-A-2009-214219

SUMMARY OF THE INVENTION

[0008]

However, in the case of a conventional glass substrate, it is not evaluated whether a surface roughness Ra of a peripheral surface portion thereof is uniform over the entire peripheral surface. Thus, this cause a problem that there is locally a portion

whose surface roughness Ra is high. In addition, sometimes, the parallelism of the main surface thereof is insufficient. That is, a glass substrate may be produced, which is large in thickness distribution in the same glass substrate. This is problematic in processing accuracy, production yield, and characteristics of a glass substrate for a magnetic recording medium.

[0009]

In view of the above problems that the related art has, the present invention aims at providing a glass substrate for a magnetic recording medium, which is configured such that when the surface roughness Ra of a side surface portion of an outer peripheral surface thereof is measured at plural places, each of the maximum value and the standard deviation of the surface roughness Ra is within a predetermined range, and which excels in parallelism when the main surface thereof is polished. In addition, the present invention aims at keeping from occurring the problems, such as the disruption of the flying attitude of a magnetic head and increase in vibrations caused at the rotation of a magnetic disk, by forming a magnetic disk using a glass substrate for a magnetic recording medium, which excels in parallelism, and by implementing a magnetic disk recording apparatus using the formed magnetic disk.

[0010]

In view of the above, the present invention has an object to provide a glass substrate for a magnetic recording medium, comprising:

a pair of main surfaces;

an outer peripheral surface; and

an inner peripheral surface,

wherein the outer peripheral surface comprises an outer peripheral side surface portion and an outer peripheral chamfered portion,

in the outer peripheral surface, when a surface roughness Ra is measured at a total of 24 measurement points, provided at intervals of 15 degrees in central angle of the glass substrate for a magnetic recording medium, with a cut-off value at 64 μm,

a maximum value of the surface roughness Ra of the outer peripheral side surface portion is 0.5 μm or less, and

a standard deviation of the surface roughness Ra of the outer peripheral side surface portion is 0.2 μm or less,

a difference in the surface roughness Ra of the outer peripheral side surface portion between adjacent measurement points on the outer peripheral surface is 0.3 μm or less,

a maximum value of a surface roughness Ra of the outer peripheral chamfered portion is 0.5 μm or less,

a standard deviation of the surface roughness Ra of the outer peripheral chamfered portion is 0.2 μm or less, and

a difference in the surface roughness Ra of the outer peripheral chamfered portion between adjacent measurement points on the outer peripheral surface is 0.3 μm or less.

[0011]

The glass substrate for a magnetic recording medium according to the present invention is configured such that when the surface roughness (i.e., an arithmetic average roughness) Ra of a side surface portion of an outer peripheral surface thereof is measured at plural places, the surface roughness Ra is within a predetermined range, and the standard deviation of the surface roughness Ra is also within a predetermined range. Thus, the glass substrate for a magnetic recording medium according to the present invention is such that, on the peripheral surface of the outer peripheral side

surface portion, there is no local place where the surface roughness Ra is high, and that the entire outer peripheral side surface portion has high smoothness. In addition, the glass substrate for a magnetic recording medium according to the present invention can be configured such that when the main surface thereof is polished, the parallelism is good.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Fig. 1 is a cross-sectional perspective view illustrating a glass substrate for a magnetic recording medium according to the present invention.

Fig. 2 is an explanatory view illustrating an outer peripheral surface measurement point and an inner peripheral surface measurement point in an embodiment according to the present invention.

Fig. 3 (A) and 3(B) are explanatory views respectively illustrating a main surface polishing device and a carrier in an embodiment according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0013]

Hereinafter, embodiments for carrying out the present invention are described with reference to the drawings. However, the present invention is not limited to the embodiments described below, and various modifications and substitutions may be made in the embodiments described below without departing from the scope of the present invention.

[0014]

As illustrated in Fig. 1, a glass substrate for a magnetic recording medium 10 has a disk-like shape having coaxial circular hole portions at a central part thereof.

[0015]

The top and bottom surfaces of the glass substrate for a magnetic recording medium 10 are main surface 11. In Fig. 1, reference numerals A1 and A6 designate the thicknesses of outer-diameter side regions of the glass substrate for a magnetic recording medium 10. Reference numerals A2 and A5 designate the thicknesses of middle regions of the glass substrate for a magnetic recording medium 10. Reference numerals A3 and A4 designate the thicknesses of inner-diameter side regions of the glass substrate for a magnetic recording medium 10.

[0016]

The more uniform the thicknesses (e.g., A1 to A6) of the regions of the glass substrate for a magnetic recording medium are, the higher the parallelism (i.e., the thickness distribution) of both of the main surfaces thereof is. On the other hand, the more non-uniform the thicknesses of the regions of the glass substrate for a magnetic recording medium are, i.e., the larger the thickness distribution (or the thickness deviation) is, the more the parallelism of both of the main surfaces thereof is degraded. The more uniform the parallelism (i.e., the thickness distribution) of both of the main surfaces is, the more uniformly the main surfaces can be polished at the polishing of the main surfaces of the glass substrate 10 for a magnetic recording medium. In addition, if a magnetic disk is formed using the glass substrate for a magnetic recording medium, the parallelism (i.e., the thickness distribution) of the main surfaces of which is uniform, and a magnetic disk recording apparatus is implemented using such a magnetic disk, the problems, such as the disruption of the flying attitude of a

magnetic head and the increase in vibrations caused at the rotation of the magnetic disc, can be suppressed.

[0017]

An outer peripheral surface 12 includes an outer peripheral side surface portion 120 perpendicular to each main surface portion, and outer peripheral chamfered portions 121 each having an angle with respect to a main surface (i.e., each inclined to a main surface).

[0018]

Similarly, an inner peripheral surface 13 includes an inner peripheral side surface portion 130 perpendicular to each main surface portion, and inner peripheral chamfered portions 131 each having an angle with respect to a main surface (i.e., each inclined to a main surface).

[0019]

The glass substrate for a magnetic recording medium according to the present invention is such that, in the outer peripheral surface of the glass substrate for a magnetic recording medium, when a surface roughness (i.e., an arithmetic average roughness) Ra is measured at a total of 24 measurement points, provided at intervals of 15 degrees in central angle of the glass substrate for a magnetic recording medium, a maximum value of the surface roughness Ra is 0.5 μm or less.

[0020]

The maximum value of the surface roughness Ra of the outer peripheral side surface portion is more preferably 0.4 μm or less. The maximum value of the surface roughness Ra thereof is even more preferably 0.3 μm or less. The maximum value of the surface roughness Ra thereof is particularly preferably 0.2 μm or less.

[0021]

In addition, the glass substrate for a magnetic recording medium according to the present invention is featured in that the standard deviation of the surface roughness Ra of the outer peripheral side surface portion of the outer peripheral surface is 0.2 μm or less. The standard deviation of the surface roughness Ra of the outer peripheral side surface portion of the outer peripheral surface is more preferably 0.15 μm or less. The standard deviation of the surface roughness Ra thereof is particularly preferably 0.1 μm or less.

[0022]

Hereinafter, the measurement points are described with reference to Fig. 2. Fig. 2 illustrates a schematic view taken from the top surface of the glass substrate according to the present invention. The measurement points on the outer peripheral surface are arranged as exemplified by arrows A to C such that two adjacent measurement points are provided at intervals of 15 degrees in central angle of the glass substrate for a magnetic recording medium (as indicated by, e.g., reference character "a" in Fig. 2). Thus, the surface roughness Ra is measured at a total of 24 measurement points in the whole outer peripheral side surface portion of the glass substrate for a magnetic recording medium. Similarly, the surface roughness Ra is measured at a total of 24 measurement points, provided at intervals of 15 degrees in central angle in case of an outer peripheral chamfered portion, an inner side surface portion and an inner peripheral chamfered portion, which are described below.

[0023]

The glass substrate for a magnetic recording medium according to the present invention is featured in that each of the maximum value and the standard deviation of the surface roughness Ra measured at the above 24 measurement points is within a predetermined range. The glass substrate for a magnetic recording medium

according to the present invention has such a range, so that, on the glass substrate, there is no local place where the surface roughness Ra is high, and that the entire circumference of the outer peripheral side surface portion of the glass substrate for a magnetic recording medium has uniform smoothness.

[0024]

In addition, the inventors of the present invention found that if the outer peripheral side surface portion of a glass substrate satisfied the above requirements, the glass substrate having main surfaces with high parallelism could be obtained when the main surfaces of the glass substrate are polished.

[0025]

This is described hereinafter.

[0026]

First, as described also in the background art section, plural glass substrates are placed in a carrier (i.e., a jig for polishing a main surface) 30 having a glass substrate retaining hole 31 capable of retaining a glass substrate, as illustrated in Fig. 3 (A).

[0027]

Next, the carrier 30 in which the glass substrates are placed is set in a double side polishing apparatus 32 illustrated in Fig. 3(B). Then, a sun gear 33 and an internal gear 34 are rotated at a predetermined rotation ratio. Consequently, the carrier is moved to revolve around the sun gear 33 while the carrier 30 is caused to rotate around an axis of rotation thereof.

[0028]

At that time, both of the main surfaces of a glass substrate retained in the carrier 30 are sandwiched and pressed between a polishing surface 36 of an upper

platen 35, which is formed by attaching a polishing pad on each surface opposed to the glass substrate, and a polishing surface 38 of a lower platen 37. In addition, a polishing solution (i.e., polishing slurry) is supplied to between each polishing surface and the glass substrate. Thus, both of the main surfaces of the glass substrate are polished simultaneously.

[0029]

The number of glass substrates that can be simultaneously polished depends upon the sizes of the carrier 30 and the double side polishing apparatus 32. For example, in the case of the 22B-type double side polishing apparatus using, e.g., a 22-inch carrier, A glass substrate lot having 150 to 222 pieces of glass substrates can simultaneously be polished. Incidentally, when polishing glass substrates, it is not necessary to set the glass substrates in all of the glass substrate retaining holes 31 of a carrier.

[0030]

Then, when the main surfaces of a glass substrate are polished, the entirety of each main surface of the glass substrate can be uniformly polished by causing the set glass substrate to rotate around an axis of rotation of the glass substrate in the associated glass substrate retaining hole 31 while the carrier rotates around an axis of rotation of the carrier and revolves around the sun gear 33.

[0031]

However, in the case of a conventional glass substrate for a magnetic recording medium, in which there is variation in the surface roughness Ra of an outer peripheral side surface portion thereof, non-uniform friction between the carrier and the glass retaining hole 31 may occur. Thus, the rotation of the glass substrate for a magnetic recording medium around an axis of rotation thereof in each glass substrate

retaining hole 31 may be suppressed. Accordingly, sometimes, the main surfaces of the glass substrate cannot entirely uniformly be polished, so that glass substrates for a magnetic recording medium, which have insufficient parallelism, may be produced.

[0032]

On the other hand, the glass substrate for a magnetic recording medium according to the present invention is such that each of the surface roughness Ra and the standard deviation thereof is within a predetermined range at the 24 measurement points. Thus, the surface roughness Ra is substantially uniform over the entire outer peripheral side surface portion of the glass substrate for a magnetic recording medium. Consequently, in a main surface polishing process, the glass substrate can uniformly rotate around an axis of rotation thereof in each glass substrate retaining hole of the carrier 30. Accordingly, the glass substrate for a magnetic recording medium, whose main surfaces have high parallelism, can be obtained.

[0033]

The glass substrate satisfies, in addition to the above requirements, the following requirement that the difference in surface roughness Ra between two adjacent measurement points on the outer peripheral side surface is 0.3 μm or less.

[0034]

The expression "two adjacent measurement points on the outer peripheral surface" means both of measurement points that adjoin a reference measurement point on the outer peripheral surface. More specifically explaining with reference to Fig. 2, in the case of employing a measurement point B as a reference measurement point, the expression "two adjacent measurement points" indicates both of the measurement points A and C adjacent to the measurement point B. The above additional requirement means that the difference in the surface roughness Ra between the

measurement point B and each of the measurement points A and C is 0.3 μm or less. In addition, the above additional requirement means that the difference in the surface roughness Ra between two adjacent measurement points among all of the measurement points is 0.3 μm or less.

[0035]

If such a prescribed-additional-requirement is satisfied, parts which are prominent in value of the surface roughness Ra are less present on the outer peripheral side surface portion, so that the outer peripheral side portion has more uniform smoothness as a whole. Thus, the above additional requirement is preferable in this respect. In addition, if the above additional requirement is satisfied, the parallelism of a glass substrate for a magnetic recording medium, which is obtained by polishing the main surfaces thereof, is enhanced. Thus, the above additional requirement is also preferable in this respect. Incidentally, the difference in the surface roughness Ra between two adjacent measurement points on the outer peripheral side surface is more preferably 0.2 μm or less. The difference in the surface roughness Ra between the adjacent measurement points is even more preferably 0.15 μm or less. The difference in the surface roughness Ra between the adjacent measurement points is particularly preferably 0.1 μm or less.

[0036]

In addition, if the surface roughness Ra is similarly measured on not only the outer peripheral side surface portion but also the outer peripheral chamfered portion, the maximum value of the surface roughness Ra of the outer peripheral chamfered portion is 0.5 μm or less, and the standard deviation of the surface roughness Ra of the outer peripheral chamfered portion is 0.2 μm or less.

[0037]

The maximum value of the surface roughness Ra of the outer peripheral chamfered portion is more preferably 0.4 μm or less. The maximum value of the surface roughness Ra of the outer peripheral chamfered portion is even more preferably 0.3 μm or less. The maximum value of the surface roughness Ra of the outer peripheral chamfered portion is particularly preferably 0.2 μm or less.

[0038]

In addition, it is more preferable that the standard deviation of the surface roughness Ra of the outer peripheral chamfered portion is 0.15 μm or less. The standard deviation of the surface roughness Ra of the outer peripheral chamfered portion is even more preferably 0.1 μm or less.

[0039]

In addition, a difference in the surface roughness Ra of the outer peripheral chamfered portion between two adjacent measurement points on the outer peripheral surface is 0.3 μm or less. The difference in the surface roughness Ra of the outer peripheral chamfered portion between two adjacent measurement points on the outer peripheral surface is more preferably 0.2 μm or less. The difference in the surface roughness Ra of the outer peripheral chamfered portion between two adjacent measurement points on the outer peripheral surface is even more preferably 0.15 μm or less. The difference in the surface roughness Ra of the outer peripheral chamfered portion between two adjacent measurement points on the outer peripheral surface is particularly preferably 0.1 μm or less.

[0040]

Here, it is noted that there are two outer peripheral chamfered portions at an upper part and a lower part of the side surface portion respectively, as illustrated in Fig. 1. In this case, it is sufficient that only one of the outer peripheral chamfered portions

satisfies the above requirements. However, it is more preferable that both of the outer peripheral chamfered portions satisfy the above requirements.

[0041]

It is preferable that the above requirements are satisfied. This is because of the facts that the entire outer peripheral surface has high smoothness, so that when such a glass substrate is used as a magnetic disk, a failure is difficult to occur. In addition, when a multilayer film having a magnetic layer is provided on the glass substrate and used as a magnetic recording medium (e.g., a magnetic disk), a film peel-off is hard to occur, so that the production yield of a film is improved. Therefore, it is preferable in this respect that the above requirements are satisfied.

[0042]

Incidentally, in the inner peripheral surface, when a surface roughness Ra is measured at a total of 24 measurement points, provided at intervals of 15 degrees in central angle of a glass substrate for a magnetic recording medium, the maximum value of the surface roughness Ra of both the inner peripheral side surface portion and the inner peripheral chamfered portion is preferably 0.5 μm or less. In addition, the standard deviation of the surface roughness Ra of both the inner peripheral side surface portion and the inner peripheral chamfered portion is preferably 0.2 μm or less. Moreover, the difference in the surface roughness Ra of both the inner peripheral side surface portion and the inner peripheral chamfered portion between two adjacent measurement points on the inner peripheral surface is preferably 0.3 μm or less.

[0043]

Incidentally, even in this case, the surface roughness Ra is measured at measurement points provided at intervals of 15 degrees in central angle on each of the inner peripheral side surface portion and the inner peripheral chamfered portion,

similarly to the case of measuring the surface roughness Ra of the outer peripheral surface. Hence, there are 24 measurement points corresponding to each of the inner peripheral side surface portion and the inner peripheral chamfered portions. The maximum value of a surface roughness Ra, the standard deviation of a surface roughness Ra, and the difference in a surface roughness Ra between two adjacent measurement points mean values of those obtained corresponding to each of the inner peripheral side surface portion and the inner peripheral chamfered portions. In addition, there are two inner peripheral chamfered portions at an upper part and a lower part of the side surface portion respectively. In this case, it is sufficient that only one of the inner peripheral chamfered portions satisfies the above requirements. However, it is more preferable that both of the inner peripheral chamfered portions satisfy the above requirements.

[0044]

If the inner peripheral side surface portion and the inner peripheral chamfered portions satisfy the above requirements, the entire inner peripheral surface has high smoothness.

[0045]

In order to use a glass substrate as a magnetic recording medium (e.g., a magnetic disk), a multilayer film having a magnetic layer is formed on the surface of the glass substrate and used as a magnetic recording medium. However, if the smoothness of each of the outer peripheral surface and the inner peripheral surface is low, that is, if the surface roughness is non-uniform and there is an abrupt change in the surface roughness, a difference in film stress may be caused, whereby a film peel-off may be caused. Consequently, the production yield of a film may be decreased. On the other hand, if the surface roughness Ra of each of the outer peripheral surface

and the inner peripheral surface satisfy the above requirements, the rate of occurrence of a film peel-off is 0 % or has a value close thereto. Thus, a high production yield can be achieved. Therefore, it is preferable that the above requirements are satisfied.

[0046]

The glass substrate for a magnetic recording medium, which has been described in the above, can be manufactured by a manufacturing method including a shape forming step, a chamfering step, a main surface lapping step, a peripheral surface polishing step, a main surface polishing step, and a precision cleaning step.

[0047]

The shape forming step is to process, into a disk-like shape, a glass sheet formed by what is called a float method, a fusion method, a downdraw method, or a press-forming method. The glass sheet is not limited to a specific one. An amorphous glass, a crystallized glass, and a reinforced glass having a reinforced layer included in a surface layer of a glass substrate can be used as a glass sheet.

[0048]

Next, a chamfering step is to perform chamfering on an inner peripheral surface, and an outer peripheral surface of a glass substrate processed into a disk-like shape in the shape forming step. In the chamfering step, a grinding stone is not limited to a specific one. The grinding stone is selected according to a necessary grinding amount, a necessary grinding speed and the like.

Chamfering processing may be one-stage processing, two-stage processing which includes two stages such as coarse processing and finish processing, or three-or-more-stage processing. Chamfering processing can be performed using grinding stones in stages, which differ from one another in the grain size, the type of a bonding agent, and the like.

[0049]

When chamfering is performed, if a coarse grinding stone is used as a grinding stone to be used in a final finish chamfering stage, a removal volume in the subsequent peripheral surface polishing step is increased to obtain a predetermined surface roughness Ra. Thus, a grinding stone whose grain size is, e.g., #400 or more is preferably used in the finish chamfering stage. A grinding stone whose grain size is, e.g., #500 or more is more preferably used in the finish chamfering stage

[0050]

A peripheral surface polishing step is to perform polishing on the side surface portions and the chamfered portions of the outer peripheral surface and the inner peripheral surface. A polishing method used in this step is not limited to a specific method. The polishing method is performed by, e.g., applying a polishing brush or a polishing pad to each of the outer peripheral surface and the inner peripheral surface and, thereby performing polishing to obtain the predetermined surface roughness Ra while supplying a polishing solution (or polishing slurry) containing abrasive thereto. At that time, it is preferable that polishing is performed in a given amount according to the coarseness (or the grain size) of the grinding stone used in the chamfering step.

[0051]

This is intended to remove a processing damaged layer (such as a flaw) generated on the surface of the glass substrate in the chamfering step by polishing the surface at a removal volume which is larger than the depth of the processing damaged layer (such as a flaw). A removal volume in the peripheral surface polishing step according to the type of a grinding stone used in the chamfering step is determined. Accordingly, the glass substrate for a magnetic recording medium having a predetermined surface roughness Ra can be obtained.

[0052]

More specifically, if a grinding stone whose grain size is, e.g., #500 is used in the finish chamfering stage, a removal volume of the peripheral surface is preferably 30 μm or more. If a grinding stone whose grain size is, e.g., #800 is used in the finish chamfering stage, a removal volume of the peripheral surface is preferably 20 μm or more.

[0053]

In the main surface polishing step, as described above, the polishing pads are applied to both of the main surfaces of the glass substrate using the double side polishing apparatus as illustrated in Fig. 3 (A) and 3(B). Then, the glass substrate is polished while a polishing solution (i.e., polishing slurry) containing abrasive is supplied to between each polishing pad and the glass substrate.

[0054]

In the precision cleaning step, particles and the like attached to the surfaces of the glass substrate are removed. Then, the glass substrate is dried.

[0055]

In the above method of manufacturing a glass substrate for a magnetic recording medium, glass substrate cleaning (i.e., cleaning between steps) and glass substrate surface etching (i.e., etching between steps) may be performed between the consecutive-steps. In addition, if a glass substrate for a magnetic recording medium requires high mechanical strength, a reinforcing step (e.g., a chemical strengthening step) of forming a reinforced layer on a surface of the glass substrate may be performed before or after the polishing step, or between the polishing steps.

[0056]

In each polishing step, only primary polishing may be performed. Alternatively, polishing may be performed in plural stages such as primary, secondary, and tertiary polishing stages.

[0057]

Incidentally, the surface roughness Ra on the side surface portion and the chamfered portions of each of the outer peripheral surface and the inner peripheral surface of the glass substrate for a magnetic recording medium is formed in the chamfering step and the peripheral surface polishing step. Thus, the surface roughness Ra of the outer peripheral surface and the inner peripheral surface of the glass substrate for a magnetic recording medium upon completion of the main surface polishing step or the precision cleaning step is the same as the surface roughness Ra obtained upon completion of the peripheral surface polishing step.

[0058]

The glass substrate for a magnetic recording medium according to the present invention can be obtained by the above manufacturing method.

[0059]

Then, a magnetic recording medium (i.e., a magnetic disk) can be obtained by additionally forming a magnetic layer and the like on the obtained glass substrate for a magnetic recording medium.

[0060]

There are two methods for recording information on a magnetic recording medium, that is, a longitudinal magnetic recording method and a perpendicular magnetic recording method. Hereinafter, a procedure of the perpendicular magnetic recording method is described by way of example.

[0061]

A magnetic recording medium includes at least a magnetic layer, a protecting layer, and a lubricating film. Then, in the case of the perpendicular magnetic recording method, generally, a soft magnetic underlayer made of a soft magnetic material, which serves to return a recording magnetic field generated from a magnetic head, is provided in the magnetic recording medium. Therefore, e.g., a soft magnetic underlayer, a nonmagnetic interlayer, a perpendicular magnetic recording layer, a protecting layer, and a lubricating layer are stacked from the surface of a glass substrate in this order.

[0062]

Each of the layers is described hereinafter.

[0063]

For example, CoNiFe, FeCoB, CoCuFe, NiFe, FeAlSi, FeTaN, FeN, FeTaC, CoFeB, CoZrN and the like can be used as the material of the soft magnetic underlayer.

[0064]

The nonmagnetic interlayer is made of Ru, Ru-alloy or the like. The nonmagnetic interlayer has a function for facilitating the epitaxial growth of a perpendicular magnetic recording layer, and another function for cutting off the magnetic exchange coupling between the soft magnetic underlayer and a perpendicular magnetic recording layer.

[0065]

The perpendicular magnetic recording layer is a magnetic film whose axis of easy magnetization is perpendicular to a substrate surface, and contains at least Co and Pt. It is advisable to cause the perpendicular magnetic recording layer to have a favorably separated micro grain structure (i.e., a granular structure) to reduce intergranular exchange coupling which causes high-level inherent medium noise.

More specifically, it is useful to use, as the material of the perpendicular magnetic recording layer, a material obtained by adding an oxide (e.g., SiO_2, SiO, Cr_2O_3, CoO, Ta_2O_3, TiO_2), or Cr, B, Cu, Ta, Zr, or the like to a CoPt-based alloy or the like.

[0066]

The soft magnetic underlayer, the nonmagnetic interlayer, and the perpendicular magnetic recording layer can continuously be manufactured by an in-line sputtering method, DC magnetron sputtering method and the like.

[0067]

Next, the protecting layer is provided to prevent the corrosion of the perpendicular magnetic recording layer and to prevent the surface of the medium from being damaged even when the magnetic head is brought into contact with the medium. The protecting layer is provided on the perpendicular magnetic recording layer. Materials containing C, ZrO_2, and SiO_2 can be used as the material of the protecting layer.

[0068]

For example, an in-line sputtering method, a chemical vapor deposition (CVD) method, and a spin coat method can be used as a method for forming the protecting layer.

[0069]

The lubricating layer is formed on the surface of the protecting layer to reduce the friction between the magnetic head and the recording medium (i.e., a magnetic disk). For example, perfluoropolyether, fluorinated alcohol, and a fluorinated carboxylic acid can be used as the material of the lubricating layer. The lubricating layer can be formed by a dip method, a spraying method, or the like.

[0070]

In the case of forming a multilayer film having a magnetic layer on the surface of the glass substrate for a magnetic recording medium according to the present invention by the above methods, the rate of occurrence of a film peel-off on the multilayer film is preferably 0.7 % or less. The rate of occurrence of a film peel-off on the multilayer film is more preferably 0.3 % or less.

[0071]

The term "rate of occurrence of a film peel-off" indicates the rate of the number of products, in each of which a film peel-off occurs after the film is formed, to 1000 products of magnetic recording media (i.e., magnetic disks). The rate of occurrence of a film peel-off is calculated by observing the surface of the glass substrates with the said multilayer film with a laser microscope, checking whether a film peel-off occurs in the magnetic recording medium, and counting the number of the products in each of which a film peel-off occurs after the film is formed.

[0072]

It is difficult to stably perform operations of reading and writing records from and to the magnetic recording medium (i.e., a magnetic disk) in which a film peel-off has occurred. Thus, the production yield of a magnetic disk drive is reduced. This is problematic.

EXAMPLE

[0073]

Hereinafter, the present invention is described by citing specific examples. However, the present invention is not limited to the following examples.

[0074]

First, an evaluation method for the glass substrate for a magnetic recording medium and an evaluation method for a magnetic recording medium on which a thin film such as a magnetic layer is formed on a surface of the glass substrate in the cases of the following examples and comparative examples are described hereinafter.

(1) Surface Roughness (Arithmetic Average Roughness) Ra of Outer peripheral surface and Inner peripheral surface

The surface roughness (i.e., the arithmetic average roughness) Ra is measured by taking an observation image having height information using a laser microscope ((Product Name: LEXT OLS 3500) manufactured by Olympus Corporation) and by analyzing the taken observation image.

[0075]

The observation image having height information taken with the laser microscope is imaged using an objective lens having a magnification of 20 times and setting an observation region of 640 μm × 640 μm. The surface roughness (i.e., the arithmetic average roughness) Ra is obtained by performing analysis on a central part of the taken observation image corresponding to the observation region of 640 μm × 640 μm (incidentally, on the center line (or central line) of the outer peripheral side surface portion in the case of, e.g., the outer peripheral side surface portion) setting a measurement length and a cut-off value at 640 μm and 64 μm, respectively.

[0076]

As described in the "DETAILED DESCRIPTION OF THE INVENTION" section, the measurement of the surface roughness (i.e., the arithmetic average roughness) Ra is performed at a total 24, measurement points provided at intervals of 15 degrees in central angle of a glass substrate for a magnetic recording medium. The chamfered portions are provided at two places on upper and lower parts of side

surface portion on each peripheral surface of the glass substrate, respectively. However, the measurement of the roughness Ra is performed on one of the chamfered portions respectively corresponding to the two places.

(2) Parallelism

The evaluation of the parallelism is performed by the following two methods. The parallelism indicates the thickness distribution of the thickness of the glass substrate. The smaller the value of the parallelism, the more uniform the thickness of the substrate. This indicates that the parallelism is excellent.

Parallelism a

The parallelism a is measured using a laser displacement sensor (a laser head is LK-G15 and an amplifier is LK-G3000V both manufactured by KEYENCE CORPORATION.). The measurement of the thickness of the glass substrate for a magnetic recording medium is performed on each of an outer peripheral portion and an inner peripheral portion at a total of eight measurement points provided at angular intervals of a central angle of 90 degrees within each main surface of the glass substrate. Then, the difference between the maximum thickness value and the minimum thickness value is obtained as the parallelism a.

Parallelism b

The parallelism b is measured using a laser interferometer (product name: Plane Measuring Fizeau Interferometer G102 manufactured by Fujinon Co., Ltd). This method is to calculate the parallelism of both of the main surfaces of a glass substrate by observing interference fringes formed due to the phase difference between reflection light rays reflected from both of the main surfaces of a glass substrate and analyzing the observed interference fringes.

[0077]

More specifically, the light and dark interference fringes observed by the laser interferometer are formed like contour lines. The interval between each pair of adjacent interference fringes is determined by the wavelength from light output from a light source and an angle of incidence of the output light. Because the laser interferometer employs the wavelength of light as a measure, the parallelism of the glass substrate for a magnetic recording medium can be measured with high precision.

[0078]

A measurement region for the parallelism b is set to include recording/reproduction area of the glass substrate (or disk) for a magnetic recording medium, whose outer diameter is 65 mm and whose inner diameter is 20 mm. According to the present embodiment, a measurement area is set as a region whose radius from the central portion of the disk ranged from 10.0 mm to 32.5 mm.

(3) Rate of Occurrence of Film Peel-off (Film Adhesion)

1000 pieces of glass substrates for a magnetic recording medium are prepared. Next, a film such as a magnetic layer is formed on a surface of each glass substrate for a magnetic recording medium. Then, the number of a magnetic recording medium in each of which film peel-off occurred is counted. Thus, the rate of occurrence of film peel-off is obtained.

[0079]

Whether film peel-off occurred is checked by observing the inner peripheral region and the outer peripheral region of each of the main surfaces of the formed magnetic recording medium using a laser microscope (product name: LEXT OLS 3500 manufactured by Olympus Corporation).

[0080]

The glass substrates for magnetic recording medium are manufactured by the following procedure.

[0081]

That is, glass substrates each containing SiO_2 as a major ingredient, which are formed by a float method, are processed into a disk-like shape having a circular hole at a central part thereof so as to obtain the glass substrate for a magnetic recording medium, each of which is 65 mm in outer diameter, 20 mm in inner diameter, and 0.635 mm in thickness.

[0082]

The inner peripheral surface and the outer peripheral surface of each of the disk-like glass substrates are chamfered (in an inner peripheral chamfering step and an outer peripheral chamfering step) to obtain the glass substrate for a magnetic recording medium, each of which is 0.15 mm in width of chamfer and 45° in angle of chamfer.

[0083]

After the chamfering, the upper and lower main surfaces of each glass substrate is subjected to lapping using alumina abrasives. Then, the abrasives are removed by cleaning.

[0084]

Next, the outer peripheral side surface portion and the outer peripheral chamfered portions of each glass substrate for a magnetic recording medium are polished using a polishing brush and a polishing solution containing cerium oxide abrasives. Thus, processing damaged layers (such as flaws) of the outer peripheral side surface portion and the outer peripheral chamfered portions are removed. In addition, each outer peripheral surface is polished so as to be a mirror surface (in an outer peripheral surface polishing step).

[0085]

After the outer peripheral surface polishing, the inner peripheral side surface portion and the inner peripheral chamfered portions of each glass substrate for a magnetic recording medium are polished using a polishing brush and a polishing solution containing cerium oxide abrasives. Thus, processing damaged layers (such as flaws) of the inner peripheral side surface portion and the inner peripheral chamfered portions are removed. In addition, each inner peripheral surface is polished so as to be a mirror surface (in an inner peripheral surface polishing step). Upon completion of polishing the inner peripheral surface, the glass substrate is subjected to ultrasonic cleaning in a state in which the glass substrate is immerged in a detergent solution. Thus, the abrasive are removed by cleaning.

[0086]

Processing methods used in the inner peripheral chamfering step and the outer peripheral chamfering step, and those used in the outer peripheral surface polishing step and the inner peripheral surface polishing step are described in Examples 1 to 8 to be described below.

[0087]

The surface roughness Ra of the outer peripheral surface (i.e., the outer peripheral side surface portion and the outer peripheral chamfered portions) and the inner peripheral surface (i.e., the inner peripheral side surface portion and the inner peripheral chamfered portions) are measured by the above method.

[0088]

Upon completion of processing the peripheral surface of each glass substrate, the upper and lower main surfaces of each glass substrate are subjected to lapping

using a fixed particle tool containing diamond abrasives and a grinding fluid. Then, each glass substrate is cleaned.

[0089]

Next, the primary polishing of each glass substrate is performed on both of the upper and lower main surfaces of each glass substrate by a double side polishing apparatus of the type 22B (product name: DSM22B-6PV-4MH (manufactured by SpeedFam Corporation)) using rigid urethane polishing pads as polishing tools, and also using a polishing solution containing cerium oxide abrasives (i.e., a polishing solution composition containing cerium oxide abrasives, whose average particle diameter (hereinafter abbreviated "average particle size") is about 1.3 μm, such that a removal volume is 20 μm. Then, the cerium oxide is removed by cleaning. Incidentally, in the present Example, a glass substrate lot having 216 pieces of glass substrates is simultaneously be polished

[0090]

After the primary polishing of the glass substrate, the secondary polishing of each glass substrate is performed on both of the upper and lower main surfaces of each glass substrate by the double side polishing apparatus of the type 22B using soft urethane polishing pads as polishing tools, and also using a polishing solution containing cerium oxide abrasive which are smaller in average particle size than the above cerium oxide abrasive for the primary polishing (i.e., a polishing solution composition containing cerium oxide as a major ingredient such that the average particle size of cerium oxide abrasive is about 0.5 μm,), such that a removal volume is 5 μm. Then, the cerium oxide is removed by cleaning.

[0091]

After the secondary polishing, the third polishing is performed on each glass substrate. The third polishing is performed on both of the upper and lower main surfaces by the double side polishing apparatus of the type 22B using soft urethane polishing pads as polishing tools and also using a polishing solution containing colloidal silica (i.e., a polishing solution composition containing colloidal silica as a major ingredient such that the average particle size of primary particles ranged from 20 nanometers (nm) to 30 nm) so that a removal volume is 1 μm.

[0092]

After the glass substrate is subjected to the third polishing, scrub cleaning using detergent, ultrasonic cleaning in a state in which the glass substrate is immerged in the detergent solution, and ultrasonic cleaning in a state in which the glass substrate is immerged in pure water, are performed in this order (i.e., precision cleaning is performed). Then, the glass substrate is dried with isopropyl alcoholic vapor.

[0093]

After the glass substrate is cleaned and dried, the parallelism a and the parallelism b of the glass substrate for a magnetic recording medium are measured.

[0094]

The surface roughness Ra of each of the outer peripheral surface (the outer peripheral side surface portion and the outer peripheral chamfered portions thereof) and the inner peripheral surface (the inner peripheral side surface portion and the inner peripheral chamfered portions thereof) of each glass substrate for a magnetic recording medium after subjected to the cleaning and the drying is measured by the above method. It is confirmed that the surface roughness Ra measured in this stage is the same as the surface roughness Ra measured after the outer peripheral surface polishing step and the inner peripheral surface polishing step.

[0095]

A multilayer film having a magnetic layer is formed on the surface of each of the obtained glass substrate for a magnetic recording medium so as to form a magnetic recording medium. Then, the adhesion of each of the multilayer film with respect to the associated glass substrate for a magnetic recording medium is evaluated.

[0096]

The formation of each multilayer film having a magnetic layer on a surface of the glass substrate for a magnetic recording medium is performed in the following procedure.

[0097]

On the surface of each glass substrate for a magnetic recording medium, which is subjected to cleaning before the film formation, a NiFe layer serving as a soft magnetic underlayer, a Ru layer serving as a nonmagnetic interlayer, a $CoCrPtSiO_2$ granular structure film serving as a perpendicular magnetic recording layer are sequentially stacked using an in-line type sputtering apparatus. Next, a diamond-like carbon film is formed by a CVD method as a protecting layer. Then, a lubricating layer having perfluoropolyether is formed by a dip method.

[0098]

Processing conditions in the inner peripheral chamfering step and the outer peripheral chamfering step, and those in the outer peripheral surface polishing step and the inner peripheral surface polishing step are described in the following Examples 1 to 8. Examples 1 to 5 correspond to examples according to the present invention, respectively. Examples 6 to 8 correspond to comparative examples, respectively.

[0099]

Table 1 describes the surface roughness Ra of each of the outer peripheral surface (i.e., the outer peripheral side surface portion and the outer peripheral chamfered portions) and the inner peripheral surface (i.e., the inner peripheral side surface portion and the inner peripheral chamfered portions) of each of the glass substrates processed under the processing conditions for Examples 1 to 8, the parallelism a and the parallelism b of each of the glass substrates for a magnetic recording medium, and the rate of occurrence of film peel-off of each of the magnetic recording medium.

(Example 1)

Chamfering is performed on the inner peripheral surface and the outer peripheral surface of each disk-like glass substrate having a circular hole at a central part thereof.

[0100]

In the chamfering step, the outer peripheral surface of each glass substrate, and the inner peripheral surface of each glass substrate are simultaneously grounded so as to be chamfered using diamond grinding stones for an outer peripheral surface, which have shapes respectively corresponding to the shapes of the chamfered portions and the side surface portion of the outer peripheral surface of each glass substrate, and diamond grinding stones for an inner peripheral surface, which have shapes respectively corresponding to the shapes of the chamfered portions and the side surface portion of the inner peripheral surface of each glass substrate. In order to enhance both of the grinding speed at the chamfering and the quality of the processed surface, the chamfering is performed in two stages, i.e., a coarse processing stage and a finish processing stage.

[0101]

The finish processing of the chamfering is performed using a resin-metal composite bond grinding stone, which grain size is #800, as both of the diamond grinding stone for an outer peripheral surface and the diamond grinding stone for an inner peripheral surface, and also using grinding liquid.

[0102]

After the chamfering, lapping is performed on the main surfaces of the glass substrate. Thus, peripheral surface polishing is performed on the outer peripheral surface (i.e., the chamfered portions and the side surface portion) and the inner peripheral surface (i.e., the chamfered portions and the side surface portion). The peripheral surface polishing is performed using polishing pads as polishing tools, and also using a polishing solution. In the case of Example 1, a removal volume corresponding to the outer peripheral surface is set at 30 μm, while a removal volume corresponding to the inner peripheral surface is set at 20 μm.

[0103]

As described above, the main surface polishing and the precision cleaning are performed on each glass substrate after the peripheral surface processing. Thus, glass substrates for a magnetic recording medium are obtained. In addition, a multilayer film having a magnetic layer is formed on a surface of each of the glass substrates for a magnetic recording medium. Thus, a magnetic recording medium is obtained. Then, the film adhesion of the multilayer film to the glass substrate for the magnetic recording medium is evaluated.

(Example 2)

Chamfering is performed on the same conditions as those in the case of Example-1 except that an electrodeposited grinding stone whose grain size is #600 is

used as both of the grinding stone for the outer peripheral surface and the grinding stone for the inner peripheral surface.

[0104]

The peripheral surface polishing is performed on the outer peripheral surface (i.e., the chamfered portions and the side surface portion) and the inner peripheral surface (i.e., the chamfered portions and the side surface portion) on the same conditions as those in the case of Example 1 except that a removal volume corresponding to the outer peripheral surface is set at 40 μm, while a removal volume corresponding to the inner peripheral surface is set at 30 μm.

(Example 3)

Chamfering is performed on the same conditions as those in the case of Example 1 except that an electrodeposited grinding stone, whose grain size is #500, is used as a finish grinding stone in the chamfering step for both of the outer peripheral surface and the inner peripheral surface.

[0105]

The peripheral surface polishing is performed on the outer peripheral surface (i.e., the chamfered portions and the side surface portion) and the inner peripheral surface (i.e., the chamfered portions and the side surface portion) on the same conditions as those in the case of Example 1 except that a removal volume corresponding to the outer peripheral surface is set at 40 μm, while a removal volume corresponding to the inner peripheral surface is set at 30 μm.

(Example 4)

Chamfering is performed on the same conditions as those in the case of Example 1 except that an electrodeposited grinding stone, whose grain size is #500, is

used as a finish grinding stone in the chamfering step for both of the outer peripheral surface and the inner peripheral surface.

[0106]

The peripheral surface polishing is performed on the outer peripheral surface (i.e., the chamfered portions and the side surface portion) and the inner peripheral surface (i.e., the chamfered portions and the side surface portion) on the same conditions as those in the case of Example 1 except that a removal volume corresponding to the outer peripheral surface is set at 40 μm, while a removal volume corresponding to the inner peripheral surface is set at 30 μm. After the peripheral surface polishing, each glass substrate is immerged in a hydrofluoric-acid/nitric-acid mixed solution. Then, the entirety of each magnetic disk is etched such that an etching amount is 7 μm.

(Example 5)

Chamfering is performed on the same conditions as those in the case of Example 1 except that an electrodeposited grinding stone, whose grain size is #500, is used as a finish grinding stone in the chamfering step for both of the outer peripheral surface and the inner peripheral surface.

[0107]

The inner peripheral surface polishing is performed on the same conditions as those in the case of Example 1 except that, before the inner peripheral surface polishing is performed, the inner peripheral surface (i.e., the chamfered portions and the side surface portion) is etched by a hydrofluoric-acid/nitric-acid mixed solution so as to set an etching amount at 15 μm, and as to set a removal volume at 7 μm. On the other hand, the outer peripheral surface polishing is performed on the same conditions

as those in the case of Example-1 except that a removal volume corresponding to the outer peripheral surface is set at 40 μm.

(Example 6)

Chamfering is performed on the same conditions as those in the case of Example 1 except that an electrodeposited grinding stone, whose grain size is #325, is used as a finish grinding stone in the chamfering step for the outer peripheral surface and that an electrodeposited grinding stone, whose grain size is #500, is used as a finish grinding stone in the chamfering step for the inner peripheral surface.

[0108]

The peripheral surface polishing is performed on the outer peripheral surface (i.e., the chamfered portions and the side surface portion) and the inner peripheral surface (i.e., the chamfered portions and the side surface portion) on the same conditions as those in the case of Example 1 except that a removal volume corresponding to the outer peripheral surface is set at 40 μm, while a removal volume corresponding to the inner peripheral surface is set at 30 μm.

(Example 7)

Chamfering is performed on the same conditions as those in the case of Example 1 except that an electrodeposited grinding stone, whose grain size is #500, is used as a finish grinding stone in the chamfering step for each of the outer peripheral surface and the inner peripheral surface.

[0109]

The peripheral surface polishing is performed on the outer peripheral surface (i.e., the chamfered portions and the side surface portion) and the inner peripheral surface (i.e., the chamfered portions and the side surface portion) on the same conditions as those in the case of Example 1 except that a removal volume

corresponding to the outer peripheral surface is set at 10 μm, while a removal volume corresponding to the inner peripheral surface is set at 30 μm.

(Example 8)

Chamfering is performed on the same conditions as those in the case of Example 1 except that an electrodeposited grinding stone, whose grain size is #325, is used as a finish grinding stone in the chamfering step for the outer peripheral surface and that another electrodeposited grinding stone, whose grain size is #500, is used as a finish grinding stone in the chamfering step for the inner peripheral surface.

[0110]

The peripheral surface polishing is performed on the outer peripheral surface (i.e., the chamfered portions and the side surface portion) and the inner peripheral surface (i.e., the chamfered portions and the side surface portion) on the same conditions as those in the case of Example 1 except that a removal volume corresponding to the outer peripheral surface is set at 20 μm, while a removal volume corresponding to the inner peripheral surface is set at 30 μm.

[0111]

According to results in the case of Examples 1 to 5, it is found that glass substrates which satisfy the requirements according to the present invention can be obtained by, e.g., assuring a removal volume corresponding to the grain size of the finish grinding stone used for the finish processing in the chamfering step.

[0112]

It can be confirmed that if the maximum value and the standard deviation of the surface roughness Ra of the outer peripheral side surface portion satisfy the requirements according to the present invention, the parallelism a and the parallelism b of the glass substrate for a magnetic recording medium are small, and that the glass

substrate for a magnetic recording medium, which excels in parallelism, can be obtained.

[0113]

In addition, In the case of Examples 1 to 4 in which each of the maximum value and the standard deviation of the surface roughness Ra of the inner peripheral side surface portion and the inner peripheral chamfered portions is within a predetermined range, and in which the difference in surface roughness between the adjacent measurement points is small, it can be confirmed that the rate of occurrence of film peel-off, especially, in the case of implementing a magnetic recording medium is 0 % to thereby increase the production yield of a magnetic recording medium.

[0114]

If results of Examples 6 to 8 are compared with those of Examples 1 to 5, it is found that, in the case of Examples 6 to 8 in which the maximum value and the standard deviation of the surface roughness Ra of the outer peripheral side surface portion do not satisfy the requirements according to the present invention, the parallelism a and the parallelism b of the glass substrate for a magnetic recording medium are poor.

[0115]

The reason is considered that as described in the embodiment of the present invention, in the case of the glass substrate in which the outer peripheral side surface portion does not satisfy the requirements according to the present invention, the upper and lower main surfaces are not uniformly polished in the main surface polishing step.

[0116]

In addition, the rate of occurrence of film peel-off in the case of implementing a magnetic recording medium from the samples according to Examples 6 to 8 is increased, as compared with the case of Examples 1 to 5.

[0117]

Thus, the glass substrate for a magnetic recording medium according to the present invention is such that the side surface portion of the outer peripheral surface has high smoothness (i.e., uniform surface roughness) as the whole. In addition, the glass substrate can be configured such that the main surfaces excel in parallelism. In the case of implementing a magnetic recording medium using such a glass substrate for a magnetic recording medium, the rate of occurrence of film peel-off is extremely low. Accordingly, the production yield of a magnetic recording medium in a magnetic recording medium manufacturing step can be increased. Thus, the cost can be reduced.

[0118]

[Table 1]

			Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6	Ex. 7	Ex. 8
Surface roughness Ra of outer peripheral surface	Outer Peripheral Side Surface Portion	Maximum Value [μm]	0.14	0.20	0.40	0.48	0.40	0.80	0.50	0.80
		Maximum Value of Difference between Two Adjacent Measurement Points [μm]	0.10	0.14	0.20	0.25	0.20	0.30	0.40	0.40
		Standard Deviation [μm]	0.05	0.07	0.14	0.16	0.14	0.20	0.24	0.30
	Outer Peripheral Chamfered Portion	Maximum Value [μm]	0.16	0.24	0.50	0.50	0.50	0.80	0.60	0.80
		Maximum Value of Difference between Two Adjacent Measurement Points [μm]	0.12	0.20	0.20	0.25	0.20	0.30	0.40	0.40
		Standard Deviation [μm]	0.06	0.10	0.18	0.18	0.18	0.20	0.26	0.30
Surface roughness Ra of inner peripheral surface	Inner Peripheral Side Surface Portion	Maximum Value [μm]	0.14	0.22	0.40	0.44	0.80	0.40	0.40	0.40
		Maximum Value of Difference between Two Adjacent Measurement Points [μm]	0.10	0.18	0.20	0.25	0.38	0.20	0.20	0.20
		Standard Deviation [μm]	0.05	0.09	0.14	0.18	0.26	0.14	0.14	0.14
	Inner Peripheral Chamfered Portion	Maximum Value [μm]	0.16	0.24	0.46	0.48	0.80	0.50	0.50	0.50
		Maximum Value of Difference between Two Adjacent Measurement Points [μm]	0.11	0.18	0.20	0.25	0.40	0.20	0.20	0.20
		Standard Deviation [μm]	0.05	0.09	0.16	0.18	0.30	0.16	0.16	0.16
Glass Substrate for Magnetic Recording Medium		Parallelism a [μm]	0.2	0.2	0.2	0.3	0.2	0.7	0.6	1.1
		Parallelism b [μm]	0.1	0.2	0.3	0.3	0.3	1.1	0.9	2.4
Magnetic Recording Medium		Rate of Occurrence of Film Peel-off (Film Adhesion) [%]	0	0	0	0	0.2	0.8	1.2	1.5

[0119]

The present application is based on Japanese Patent Applications No. 2011-213463 filed on September 28, 2011, and the contents of which are incorporated herein by reference.

DESCRIPTION OF REFERENCE NUMERALS AND SIGNS

[0120]

10...glass substrate for a magnetic recording medium

12...outer peripheral surface

120...outer peripheral side surface portion

121...outer peripheral chamfered portion

13...inner peripheral surface

130...inner peripheral side surface portion

131...inner peripheral chamfered portion

WHAT IS CLAIMED IS:

1. A method for producing a glass substrate for a magnetic recording medium, the glass substrate comprising:

a pair of main surfaces;

an outer peripheral surface; and

an inner peripheral surface,

wherein the outer peripheral surface comprises an outer peripheral side surface portion and an outer peripheral chamfered portion,

the method comprises a main surface polishing process, in which a main surface of the glass substrate for a magnetic recording medium retained in a carrier using a double side polishing apparatus is polished, and

in an outer peripheral surface of a glass substrate for a magnetic recording medium to be polished in the main surface polishing process,

when a surface roughness Ra is measured at a total of 24 measurement points, provided at intervals of 15 degrees in central angle of the glass substrate for a magnetic recording medium,

a maximum value of the surface roughness Ra of the outer peripheral side surface portion is 0.5 μm or less, and

a standard deviation of the surface roughness Ra of the outer peripheral side surface portion is 0.2 μm or less.

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

wherein in the glass substrate for a magnetic recording medium to be polished in the main surface polishing process,

a difference in the surface roughness Ra of the outer peripheral side surface portion between adjacent measurement points on the outer peripheral surface is 0.3 μm or less.

3. A glass substrate for a magnetic recording medium, comprising:

a pair of main surfaces;

an outer peripheral surface; and

an inner peripheral surface,

wherein the outer peripheral surface comprises an outer peripheral side surface portion and an outer peripheral chamfered portion,

the glass substrate is obtained through a main surface polishing process in which a main surface of the glass substrate for a magnetic recording medium retained in a carrier is polished using a double side polishing apparatus, and

in an outer peripheral surface of the glass substrate for a magnetic recording medium,

when a surface roughness Ra is measured at a total of 24 measurement points, provided at intervals of 15 degrees in central angle of the glass substrate for a magnetic recording medium,

a maximum value of the surface roughness Ra of the outer peripheral side surface portion is 0.5 μm or less, and

a standard deviation of the surface roughness Ra of the outer peripheral side surface portion is 0.2 μm or less.

4. The glass substrate for a magnetic recording medium according to claim 3,

wherein a difference in the surface roughness Ra of the outer peripheral side surface portion between adjacent measurement points on the outer peripheral surface is 0.3 μm or less.

5. The glass substrate for a magnetic recording medium according to claim 3 or 4,

wherein a maximum value of a surface roughness Ra of the outer peripheral chamfered portion is 0.5 μm or less,

a standard deviation of the surface roughness Ra of the outer peripheral chamfered portion is 0.2 μm or less, and

a difference in the surface roughness Ra of the outer peripheral chamfered portion between adjacent measurement points on the outer peripheral surface is 0.3 μm or less.

6. The glass substrate for a magnetic recording medium according to any one of claims 3 to 5,

wherein the inner peripheral surface comprises an inner peripheral side surface portion and an inner peripheral chamfered portion,

in the inner peripheral surface, when a surface roughness Ra is measured at a total of 24 measurement points, provided at intervals of 15 degrees in central angle of the glass substrate for a magnetic recording medium,

a maximum value of a surface roughness Ra of both the inner peripheral side surface portion and the inner peripheral chamfered portion is 0.5 μm or less,

a standard deviation of the surface roughness Ra of both the inner peripheral side surface portion and the inner peripheral chamfered portion is 0.2 μm or less, and

a difference in the surface roughness Ra of both the inner peripheral side surface portion and the inner peripheral chamfered portion between adjacent measurement points on the inner peripheral surface is 0.3 μm or less.

7. The glass substrate for a magnetic recording medium according to any one of claims 3 to 6,

wherein, when a multilayer film having a magnetic layer is formed on a surface of the glass substrate for a magnetic recording medium, a rate of occurrence of film peel-off on the multilayer film is 0.7 % or less.