

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

The present disclosure relates to subject matters contained in Japanese Patent Application No filed on, which are expressly incorporated herein by reference in their entireties.

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a manufacturing method of a glass substrate for a magnetic disc mounted on a magnetic disc device such as a hard disc drive (HDD) and a manufacturing method of a magnetic disc.

Description of the Related Art

[0002] As an information recording medium for an information processing device such as a hard disc drive, a magnetic disc is known. A magnetic disc is configured by depositing a thin film such as a magnetic layer on a substrate and aluminum has been used as the substrate. However, for the purpose of improving recording density, it has been demanded to further lower the flying height between a substrate of the HDD and a magnetic head. Therefore, a glass substrate which can lower the flying height of a magnetic disc compared to an aluminum substrate has been replacing aluminum.

[0003] To lower the magnetic head, smoothness of the surface of the glass substrate being a substrate is a must. In

a glass substrate for a perpendicular magnetic recoding type which requires especially strict quality demand, influence to magnetic characteristics by a minute defect of 20 nm level has been reported and it is requested to manage and reduce such a minute defect.

[0004] Therefore, high recording density is achieved by carrying out a plurality of times of polishing with high precision on the glass substrate surface. Generally, rough polishing is carried out in the first polishing and mirror polishing is carried out in the second polishing. Particle diameter of abrasive agent used in the second polishing is smaller than that used in the first polishing.

[0005] However, if a foreign matter such as abrasive agent attaches on the substrate, high smoothness cannot be obtained. Therefore, there is a limitation in achieving high recoding density of a magnetic disc only by polishing. Therefore, a cleansing step for removing abrasive agent after polishing has been conventionally introduced and a foreign matter such as abrasive agent has been removed. In the cleansing step, cleansing mainly by use of a surface active agent is carried out.

[0006] After polishing by cerium oxide series abrasive agent, a projection which cannot be removed by normal cleansing remains. Therefore, for example, in the Patent Document 1, a technique to cleanse by use of acid, a reducing agent, and fluorine ion following polishing by cerium series abrasive agent has been disclosed. Moreover, in the Patent Document 2,

a technique to cleanse a substrate, which was polished by cerium series abrasive agent, by use of cleansing liquid with controlled fluorine ion concentration so that a concave portion does not occur on the glass substrate surface after cleansing (by AFM observation) has been disclosed.

[Patent Document 1] Japanese Published Unexamined Patent Application No. 2004-59419

[Patent Document 2] Japanese Published Unexamined Patent Application No. 2006-99847

[0007] However, when a substrate was manufactured through cleansing by the cleansing liquid described in the conventional art, a plurality of magnetic recording medium regarded as defective were found. Then, when a cause of defect was investigated, it was found out that cerium series abrasive agent remained on the substrate surface and this caused defect. This is because the portion where the abrasive agent remains becomes a mask and generates a convex portion.

[0008] In view of the above-mentioned problem, the inventors of the present invention investigated manufacturing process of a case where the cerium series abrasive agent remained on the substrate surface. The inventors focused on a fact that in a rough polishing step to roughly polish the glass surface, abrasive agent including cerium series abrasive grain was used and in the final mirror polishing step to finish the surface of the glass substrate, abrasive agent including silica series abrasive grain which has smaller particle diameter than that of cerium series was used.

[0009] Then, as a result of further discussion on this fact, the inventors found out that because material of abrasive grain used in the rough polishing step and in the final mirror polishing step differs from each other, cleansing liquid used in a cleansing step following each of the steps remained and cerium series abrasive agent which was not removed in the rough polishing step remained even after cleansing step following the final mirror polishing was carried out.

[0010] As such, there is a problem that if abrasive agent used in the rough polishing step remains to the mirror polishing step even though cleansing was carried out, this can be a defect that greatly influences substrate surface quality such as a mound or a scratch. Incidence ratio of a mound becomes higher as abrasive agent particle diameter ratio becomes larger. Especially, when colloidal silica was used to polish following polishing by use of cerium, abrasive agent particle ratio becomes large and therefore incidence ratio of a mound becomes large.

[0011] To remove cerium series abrasive agent, as described in the Patent Documents 1 and 2, it is necessary to cleanse by use of cleansing liquid including acid, a reducing agent, and fluorine ion. However, because abrasive grain used in the rough polishing step and the mirror polishing step are cerium and colloidal silica, respectively, following the mirror polishing step, cleansing liquid for removing silica series abrasive agent must be used and cerium series abrasive agent cannot be removed.

[0012] However, if cleansing liquid including acid, a reducing agent, and fluorine ion is used as described in the Patent Document 2, surface roughness is increased due to the cleansing and smoothness of a final magnetic disc is lost.

SUMMARY OF THE INVENTION

[0013] The present invention has been made in consideration of the above problem and present cleansing method and is aimed at providing a manufacturing method of a glass substrate for a magnetic disc and a manufacturing method of a magnetic disc which can remove cerium series abrasive grain by cleansing after rough polishing step without fail by modifying composition of a cleansing liquid used in cleansing step and can manufacture a fine product.

[0014] To solve the above mentioned problem, the inventors of the present invention made a research on the shape of a substrate surface required for a substrate after polishing by cerium using a substrate polished by cerium oxide abrasive agent. As a following step after a rough polishing step using cerium oxide abrasive agent (first polishing step), there is a final mirror surface polishing step (second polishing step). Therefore, surface roughness is permitted to a certain degree. Therefore, a cleansing liquid for more surely removing abrasive agent is developed by adding etching function to carry out etching of a substrate surface to a conventionally-proposed cleansing liquid for removing cerium oxide abrasive grain by dissolution so that cerium oxide on the substrate surface can

be removed by dissolution in a short period of time and by etching effect of several nm of the substrate surface. In a case where the abrasive agent includes cerium oxide, liquid which can carry out reductive dissolution of the abrasive agent is used. Specifically, solution including inorganic acid, organic acid, and fluorine ion is used.

[0015] The present invention includes following configuration.

[0016]

(Configuration of Invention 1)

According to one aspect of the present invention, the present invention is a manufacturing method of a glass substrate for a magnetic disc including a rough polishing step for roughly polishing a main surface of a glass substrate, a mirror polishing step for mirror polishing the main surface of the glass substrate after the rough polishing step, and a cleansing step for cleansing the glass substrate between the rough polishing step and the mirror polishing step, wherein in the rough polishing step, abrasive agent including rare-earth oxide in which content of fluorine is 5% by weight or less as a main component is supplied to the glass substrate and an abrasive cloth and the glass substrate are relatively moved to roughly polish the main surface of the glass substrate; in the mirror polishing step, abrasive agent which is different from one including rare-earth oxide as a main composition is supplied to the glass substrate and an abrasive cloth and the glass substrate are relatively moved to mirror polish the main surface

of the glass substrate; and in the cleansing step, the abrasive agent including rare-earth oxide as a main composition is molten and removed and the glass substrate main surface is etching processed with a cutting stock smaller than the cutting stock of the glass substrate main surface in the mirror polishing step.

[0017] According to the above configuration, it is possible to carry out etching processing by a cleansing liquid after rough polishing deeper than conventional method and therefore it is possible to more effectively remove abrasive agent attached on the glass substrate main surface. This is because it is known in advance that mirror polishing (second polishing) will be carried out after rough polishing (first polishing) and therefore if surface roughness increases due to etching accompanying cleansing after rough polishing, as long as a condition that the surface roughness occurs within a range of cutting stock which will be cut later in the mirror polishing step is fulfilled, no influence is given to the smoothness of the final glass substrate main surface after mirror polishing.

[0018]

(Configuration of Invention 2)

Moreover, according to another configuration of the present invention, the present invention is a manufacturing method of a glass substrate for a magnetic disc including a rough polishing step for roughly polishing a main surface of a glass substrate, a mirror polishing step for mirror polishing the main surface of the glass substrate after the rough polishing step

by use of an abrasive agent which is a different abrasive agent from that used in the rough polishing step, and a cleansing step for cleansing the glass substrate between the rough polishing step and the mirror polishing step, wherein in the rough polishing step, abrasive agent including rare-earth oxide in which content of fluorine is 5% by weight or less of as a main component is supplied to the glass substrate and an abrasive cloth and the glass substrate are relatively moved to roughly polish the main surface of the glass substrate; and in the cleansing step, the glass substrate is caused to come into contact with a cleansing liquid including ascorbic acid, 100 ppm or more and 1000 ppm or less fluorine ion, and sulfuric acid of 3% by weight or more to remove by dissolving the abrasive agent including rare-earth oxide as a main composition.

[0019] Fluorine ion plays a role of a catalyst for enhancing removal by dissolution of the abrasive agent including rare-earth oxide such as cerium oxide as a main composition. According to the above configuration, since concentration of fluorine ion is set to 100 ppm or more and 1000 ppm or less, removal by dissolution of the abrasive agent is enhanced more.

[0020] It is more preferable if concentration of fluorine ion is set to 100 ppm or more and 300 ppm or less. Supply source of fluorine ion may be hydrofluoric acid, silicofluoric acid, sodium fluoride, or the like.

[0021] Moreover, according to the present invention, due to increase of etching depth caused by high fluorine ion

concentration, abrasive agent including rare-earth oxide such as cerium oxide as a main component can be more effectively removed in the cleansing step after rough polishing. Further, even if surface becomes rough by etching, the roughness is within a range of cutting stock to be cut in the following mirror polishing step. Therefore, no influence is given to the smoothness of the final glass substrate main surface after mirror polishing.

[0022] It is preferable that the cleansing liquid is used in immersion cleaning. However, the cleansing liquid may be supplied by spraying. Moreover, although it is sufficient with only immersion cleaning, ultrasonic may also be used. Further, scrub cleansing or the like may also be used to increase cleansing effect. In addition, by substituting atmosphere of a washing tank, life of the liquid can be lengthened.

[0023] Here, it is preferable that concentration of ascorbic acid included in the above cleansing liquid is set to 0.1% by weight or more and it is more preferable if the concentration is set to 0.5% or more and 3% or less by weight. Ascorbic acid used in the cleansing liquid may be L-ascorbic acid and may be supplied as L-ascorbic acid salt. Generally, there are two types of ascorbic acid: reduced ascorbic acid and oxidized ascorbic acid. Moreover, from viewpoint of constitutional isomer, there are xylo and arabo. Further, from viewpoint of optical isomer, there are L and D. One that is generally called ascorbic acid is reduced ascorbic acid.

[0024] The reduced type ascorbic acid includes L-(xylo)

ascorbic acid which is vitamin C, D-arabo (iso) ascorbic acid which is erythorbic acid, and the like. Reducing oxidized ascorbic acid includes dehydroascorbic acid, monodehydroascorbic acid, and the like.

[0025]

(Configuration of Invention 3)

It is preferable that in the above cleansing step, abrasive agent including rare-earth oxide a main component is removed by dissolution so that the number of abrasive grains included in the abrasive agent including rare-earth oxide as a main component existing on the main surface of the glass substrate becomes $2/\text{cm}^2$.

[0026]

(Configuration of Invention 4)

According to another aspect of the present invention, a magnetic disc manufacturing method according to the present invention forms at least a magnetic layer on a glass substrate manufactured by any of the above methods.

[0027] According to the present invention, it is possible to more effectively remove the abrasive agent including rare-earth oxide as a main component, which is used in the rough polishing step, in the cleansing step following the rough polishing step in a case where different abrasive agents are used in the rough polishing step and the mirror polishing step after the rough polishing step of the glass substrate. Moreover, even if surface becomes rough due to etching by the above-mentioned cleansing, that occurs within a range of

cutting stock to be cut in the following mirror polishing step and therefore no influence is given to the smoothness of the final glass substrate main surface after mirror polishing.

[0028] Therefore, amount of abrasive agent which remains until the mirror polishing step becomes small and a magnetic disc manufactured by the manufacturing method of the present invention can reduce defects such as mound or scratch.

BRIEF DESCRIPTION OF THE DRAWINGS

[0099]

[FIG. 1] A view showing an effect of an embodiment of the present invention.

[FIG. 2] A view showing relation between fluorine concentration and etching speed in the embodiment of the present invention.

The Best Mode for Carrying Out the Claimed Invention

[0029] Next, embodiments of a manufacturing method of a glass substrate for a magnetic disc and a manufacturing method of a magnetic disc according to the present invention will be explained in detail.

[0030] When the inventors made up various cleansing reagents to compare dissolution property to cerium oxide (cerium dioxide) which is main component of the abrasive agent, it was confirmed that fine dissolution property can be obtained by processing liquid including sulfuric acid and ascorbic acid. Especially, it was confirmed that quick dissolution property

can be obtained by providing fluorine ion by addition of fluoric acid or sodium fluoride as an additive agent to the processing liquid including sulfuric acid and ascorbic acid.

[0031] Other than cerium oxide, dissolution property of rare-earth oxide such as lanthanum oxide, praseodymium oxide, neodymium oxide and the like were confirmed. Then, it was confirmed that dissolution property similar to that of cerium oxide can be obtained. Rough polishing of a glass substrate was practically carried out by use of abrasive agent including cerium oxide series abrasive agent and thereafter, cleansing was carried out by use of cleansing liquid including sulfuric acid, ascorbic acid, and fluorine ion. Then, irrespective of concentration of sulfuric acid, a protrusion (convex portion) formed by attachment of abrasive agent on the glass substrate could be removed.

[0032] However, when observed carefully by an atomic force microscope, it was found out that when cleansing liquid having low concentration of sulfuric acid comes into contact with the glass substrate, a small bore (concave portion) is generated on the glass substrate surface. Specifically, it was found out that the concave portion was generated on the glass substrate surface when concentration of sulfuric acid is less than 3% by weight. In case of a cleansing liquid including sulfuric acid, ascorbic acid, and fluorine ion, it is assumed that when concentration of sulfuric acid was lower than 3% by weight, sulfuric acid exerts leaching effect to the glass, changes the surface thereof, and increases surface roughness.

[0033] Here, leaching is a phenomenon that in a multicomponent glass such as aluminosilicate glass, material of the glass which can be dissolved by acid is dissolved while maintaining frame of the glass (SiO frame). Leaching markedly occurs in a multicomponent glass where an element other than SiO is included. Leaching is a different phenomenon from etching, where glass itself is dissolved.

[0034] Therefore, it was found out that to prevent formation of a concave portion on the glass substrate surface, an embodiment of the present invention needs cleansing liquid including sulfuric acid, ascorbic acid, and fluorine ion wherein content of sulfuric acid must be at least 1.5% by weight or more and especially 3% by weight or more. Here, instead of sulfuric acid, nitric acid or hydrochloric acid may be used. However, sulfuric acid which does not get consumed by cross-interaction with ascorbic acid, which is a reducing agent, is most suitable.

[0035] Moreover, it was found out when the inventors cleansed a glass substrate using this cleansing liquid that depending on the type of cerium oxide series abrasive agent, generation aspects of the convex portion or concave portion on the glass substrate differ. There are a plurality of cerium oxide series abrasive agent used for mirror polishing of a glass substrate depending on manufacturing method or the like. Moreover, in the cerium oxide series abrasive agent, cerium oxide is a main component while other rare-earth oxide such as lanthanum oxide, praseodymium oxide, and neodymium oxide are

included. In other words, the cerium oxide series abrasive agent is rare earth oxide series abrasive agent including cerium oxide as a main component.

[0036] Currently (as of year 2007), there are two types of cerium oxide series abrasive agent which can be relatively easily obtained: a cerium oxide series abrasive agent manufactured through processing such as calcinations with a bastnaesite ore including fluorine substance as a raw material; and a cerium oxide series abrasive agent manufactured through processing such as calcinations with purified rare-earth compound as a raw material. The former cerium oxide series abrasive agent includes an ore which has fluorine substance by itself and therefore fluorine is included as rare-earth oxide. The latter cerium oxide series abrasive agent does not include fluorine or if it does, limited to a very small amount. Here, fluorine content in the abrasive agents can be measured as fluorine atom content by an X-ray photoelectron spectroscopy (XPS) or the like.

[0037] When cleansing property of cleansing liquids including sulfuric acid (concentration of sulfuric acid must be 3% by weight or more), ascorbic acid, and fluorine ion according to an embodiment of the present invention to the above-mentioned various procurable cerium oxide series abrasive agent including fluorine was compared, it was found out that in the case of abrasive agent having fluorine concentration, which is in a higher predetermined range than conventional one, due to increase in dept of etching caused by

high concentration of fluorine ion, abrasive agent including cerium oxide as a main composition can be effectively removed in the cleansing step following the rough polishing.

[0038] Moreover, it was also found out that even if surface becomes rough due to etching, the roughness is within a range of cutting stock to be cut in the following mirror polishing step. Therefore, no influence is given to the smoothness of the final glass substrate main surface after mirror polishing.

[0039] From this viewpoint, the inventors found out that in a case where a glass substrate for a magnetic disc is cleansed between the rough polishing step (first polishing step) and the mirror polishing step (second polishing step) using the cleansing liquid of the embodiment of the present invention, fluorine concentration in the cleansing liquid need to be between 100 ppm and 1000 ppm and more preferably, between 100 ppm and 300 ppm.

[0040] The cleansing liquid has dissolution enhancing effect by fluorine ion to cerium oxide in the cleansing liquid in addition to etching effect by acid such as sulfuric acid and reducing effect of cerium oxide by reduced agent such as ascorbic acid. Therefore, the cleansing liquid materialized by synergetic effect of the three components have quite high detergency toward cerium oxide and can remove a foreign matter on the glass substrate surface by a slight amount of etching that does not damage the substrate surface.

[0041] The above mentioned effect of the cleansing liquid depends on the combination of a solution for reductive

dissolution from the state of oxide, that is, reduced agent having sufficiently low redox potential to a redox potential of a specific element among solution reactivity, and a complexing agent to cause a metal to form a soluble metal complex. Hard acid forms a complex with a hard base, while soft acid forms a complex with a soft base.

[0042] According to acid-base concept by Lewis, a metal ion is acid and a ligand is a base. Pearson organized stability of a complex by Lewis' acid-base concept and suggested a concept of hard and soft acid base. In a case of a metal ion or a ligand having a large polarization, electric charge thereof easily moves and therefore, such a metal ion or a ligand is called "soft", while electric charge of a metal ion or a ligand having small polarization does not move easily and therefore such a metal ion or a ligand is called "hard".

[0043] Ce^{4+} and La^{3+} which are components of the abrasive agent belong to hard acid and can form a stable complex with a hard base. Therefore, addition of fluorine ion can enhance reaction. By setting concentration of fluorine ion between 100 ppm and 1000 ppm, which is significantly high, in addition to conventional configuration for dissolving cerium abrasive agent, a substrate surface can be etched.

[0044] In a case where cerium oxide is used as abrasive agent, by use of cleansing liquid which can carry out reduction dissolution, specifically solution including inorganic acid, organic acid, and fluorine ion, for cleansing, cerium oxide which is abrasive agent remaining on the substrate surface can

be selectively dissolved. Thus, it becomes possible to suppress residue of abrasive agent to a following step while reducing damage by etching to the substrate. This enables to suppress generation of a mound by residue of an abrasive agent in the previous step. From this result, reduction of mound and scratch can be expected.

[0045] In the embodiment of the present invention, if concentration of sulfuric acid included in the cleansing liquid of the glass substrate is 3% by weight or more, generation of a concave shape on the glass substrate surface can be suppressed. However, thinking from a viewpoint of, for example, improving dissolution speed and production efficiency, concentration of sulfuric acid in practical use can be 4% by weight or more. Moreover, if concentration of sulfuric acid is increased, production efficiency is increased as well. However, if the concentration exceeds 30% by weight, dissolution speed of cerium oxide is slowed, contrary to assumption, and therefore this is not preferable. From this viewpoint, it is preferable to limit concentration of sulfuric acid to 30% by weight or less. Moreover, in a case of cerium oxide series abrasive agent including fluorine, because reaction is caused between rare-earth fluorine and sulfuric acid, it is not preferable to increase concentration of sulfuric acid. From this viewpoint, it is preferable to set concentration of sulfuric acid to 30% by weight or less, especially, to 10% by weight or less.

[0046] In the embodiment of the present invention, ascorbic acid included in the cleansing liquid of a glass

substrate may be L-ascorbic acid. Ascorbic acid may be supplied in the form of L-ascorbic acid salt. Concentration of ascorbic acid included in the cleansing liquid can be adjusted within a range which can retain predetermined dissolution property to the abrasive agent. For example, the concentration may be 0.1% by weight. If the concentration is lower than 0.1% by weight, there may be a case where dissolution speed is slowed and production efficiency is worsened. Taking production speed into consideration, it is preferable that the concentration is between 0.5 and 1.0% by weight. Although upper limit of concentration of ascorbic acid should not be especially limited, practical concentration can be lower than 4% by weight. However, in the vicinity of 4% by weight is near saturation concentration of ascorbic acid and it is difficult to compose the cleansing liquid. Therefore, taking production efficiency into consideration, it is preferable to set concentration to 3% by weight or less. In the vicinity of 3% by weight, composition of the cleansing liquid can be carried out quickly and therefore, production efficiency can be improved.

[0047] Here, in the fluoride cerium oxide series abrasive agent, fluoric acid is generated by reaction between rare-earth fluoride substance and sulfuric acid included in the cleansing liquid. Therefore, in the embodiment of the present invention, concentration of sulfuric acid must be managed in ppm level. Especially, when fluoric acid included in the abrasive agent exceeds 5% by weight, there may be a case where management of fluorine ion concentration in the cleansing liquid is

difficult.

[0048] In the embodiment of the present invention, there is no limitation for the abrasive agent used in mirror polishing of a glass substrate as long as the abrasive agent includes rare-earth oxide with 5% by weight or less of fluorine content as a main component. Especially, it is preferable that the abrasive agent is cerium oxide series abrasive agent including cerium oxide as a main component. Here, the abrasive agent including rare-earth oxide with 5% by weight or less of fluorine content as a main component means that the abrasive agent does not include fluorine or even if included, the abrasive agent includes rare-earth oxide as a main component where content of fluorine is 5% by weight or less. Moreover, content of fluorine means content of fluorine atom included in the abrasive agent. Fluorine atom is included as fluorine containing substance (fluoride or fluorine) in the abrasive agent. In a case where fluorine is included in the abrasive agent, fluorine content may be preferably 3% by weight or less.

[0049] Methods for rough polishing and mirror polishing in the embodiment of the present invention are not especially limited. However, surface of a glass substrate may come into contact with an abrasive cloth and while abrasive agent is supplied, the abrasive cloth and the glass substrate may be relatively moved to polish the surface of the glass substrate. As the abrasive cloth, an abrasive pad may be used. It is preferable that the abrasive pad is soft polisher. Hardness of the abrasive pad may be, in the case of rough polishing, around

90 by Ascar C hardness. It is preferable in the case of the mirror polishing to set between 60 and 80 by Ascar C hardness.

[0050] It is preferable that contacting portion of the abrasive pad and the glass substrate is resin foam having foamed opening pores, especially foamed polyurethane. Average particle diameter of abrasive grain included in the abrasive agent (in the case of the embodiment of the present invention, abrasive grain having cerium oxide as a main component) may be between 0.1 and 1 μm . If polishing is carried out in this condition, it is possible to mirror polish the surface of a glass substrate.

[0051] It is preferable that in the embodiment of the present invention, glass included in the glass substrate is amorphous aluminosilicate glass. It is possible to make a surface of this type of glass into a smooth mirror surface by mirror polishing. As such an aluminosilicate glass, one which includes between 58 and 75% by weight of SiO_2 , between 5 and 23% by weight of Al_2O_3 , between 3 and 10% by weight of Li_2O , and between 4 and 13% by weight of Na_2O as main components may be used (however, an aluminosilicate glass not including phosphorus oxide).

[0052] For example, the glass may be an amorphous aluminosilicate glass which includes 58 and 75% by weight of SiO_2 , between 5 and 23% by weight of Al_2O_3 , between 3 and 10% by weight of Li_2O , between 4 and 13% by weight of Na_2O , and between 5.5 and 15% by weight of ZrO_2 as main components while ratio by weight of $\text{Na}_2\text{O}/\text{ZrO}_2$ is between 0.5 and 2.0, ratio by weight

of $\text{Al}_2\text{O}_3/\text{ZrO}_2$ is between 0.4 and 2.5 and does not include phosphorus oxide. Here, it is preferable that the glass does not include alkaline earth metal oxide such as Cao or Mgo. Such a glass includes N5 glass (brand name) of HOYA Corporation.

[0053] There may be a case where an aluminosilicate glass is influenced by leashing effect caused by contact with sulfuric acid, resulting in change of surface of the glass substrate and rough surface roughness. The cleansing liquid of the embodiment of the present invention includes a composition that can deal with such a problem, as mentioned above, and therefore is preferable.

[0054] It is preferable that in the embodiment of the present invention, surface of a glass substrate after cleansing processing is a mirror surface with a maximum depth R_v of a concave portion is 4 nm or less. If R_v exceeds 4nm, that is, the concave portion is deep, there may be a case where float position of a magnetic head float flying at around 10 nm or less is disturbed and also there is a possibility that fly stiction may occur. More over, it is preferable that the surface is a mirror surface having a maximum roughness R_{max} of 6 nm or less. Such mirror surface condition can be realized by carrying out the mirror surface processing and cleansing processing of the embodiment of the present invention in this sequence.

[0055] It is preferable that a chemical strengthening processing is carried out after the cleansing processing in the present embodiment. A method of the chemical strengthening processing includes, for example, low temperature ion exchange

method for carrying out ion exchange between, for example, 300 and 400°C, which does not exceed glass transition point. Chemical strengthening processing is processing to cause molten chemical strengthening salt to be contacted with a glass substrate to cause an alkali metal element having a relatively large atom diameter in the chemical strengthening salt to be ion exchanged by an alkali metal element having a relatively small atom diameter in the glass substrate and the alkaline metal element having a large atom to permeate into the surface layer of the glass substrate so that compression stress is generated on the surface of the glass substrate. A chemically strengthened glass substrate has superior anti-shock property and therefore it is preferable that it is mounted on an HDD for a mobile use. Alkali metal nitric acid such as potassium nitrate or sodium nitrate can be preferably used as the chemical strengthening salt.

[0056] Since the surface of the glass substrate according to the embodiment of the present invention is mirror surface and abrasive agent is removed without fail, by carrying out the chemical strengthening processing, uniform compression stress can be generated on the surface of the glass substrate. If the chemical strengthening processing of the glass substrate is carried out without efficiently removing the abrasive agent, in a process where ion exchange processing is carried out in the temperature of, for example, between 300 and 400°C, the abrasive agent sticks to the glass substrate and cannot be easily removed.

[0057] Moreover, glass right beneath the sticking abrasive agent is prevented from generating compression stress and therefore that portion may be transformed to have a convex or concave shape. Since an average particle diameter of the abrasive agent used in the mirror polishing processing is between 0.1 and 1.0 μm or so, there may be a case where deformation or convex or concave shape deformation corresponding to that size may occur. According to the embodiment of the present invention, the abrasive agent can be removed without fail and at the same time, surface of the glass substrate to which the chemical strengthening processing is carried out is a mirror-surfaced smooth surface without a convex or concave portion. Therefore, after the chemical strengthening processing, a mirror-surfaced smooth surface without a convex or concave portion can be maintained.

[0058] In the embodiment of the present invention, tape polishing processing can be carried out after the cleansing processing. In the embodiment of the present invention, surface of the glass substrate subjected to the tape polishing processing is a mirror-surfaced smooth surface without a convex or concave portion and therefore there is no fear of damaging the surface shape by biting a foreign matter in the tape polishing processing.

[0059] Recently, there is a case where magnetic anisotropy which matches circumferential direction of the disc is provided to the magnetic layer of a magnetic disc for the purpose of improving information recording density of the magnetic head.

Circumferential of the disc is moving direction of the magnetic head and therefore, if magnetic anisotropy is provided along this direction, this serves for high recording density. By carrying out the tape polishing processing on the surface of the disc shaped glass substrate, a texture including a line oriented in the circumferential direction of the disc can be formed. When a magnetic layer is formed on this texture processed glass substrate, it is possible to generate magnetic anisotropy to the circumferential direction of the disc.

[0060] In this texture processing, a diamond abrasive agent is used as an abrasive agent in the tape polishing processing. A polishing tape and a glass substrate are caused to come into contact, diamond abrasive agent is supplied, and the polishing tape and the glass substrate are relatively moved so that a texture is formed on the surface of the glass substrate. If a foreign matter is attached or a convex or concave portion is generated on the surface of the glass substrate at this time, formation of a desired texture is prevented. Therefore, it becomes difficult to add predetermined magnetic anisotropy to the magnetic disc. Because the surface of the glass substrate according to the embodiment of the present invention is a mirrored smooth surface without a convex or concave portion, it is possible to form uniform texture even in a fine region. Therefore, the embodiment of the present invention contributes to high recording density of the magnetic disc.

[0061] In the embodiment of the present invention, the magnetic disc is manufactured by forming at least a magnetic

layer on the glass substrate for a magnetic disc. As a material of the magnetic layer, CoPt series ferromagnetic alloy which is hexagonal system having large magnetic anisotropy can be used. As a forming method of the magnetic layer, sputtering method, for example, a method of depositing a magnetic layer on a glass substrate by DC magnetron sputtering method, may be used. Moreover, by inserting a foundation layer between the glass substrate and the magnetic layer, orientation direction of a magnetic grain or size of the magnetic grain in the magnetic layer can be controlled.

[0062] For example, by use of a cubic system such as Cr series alloy, it is possible to cause easy direction of magnetization of the magnetic layer to be oriented along the magnetic disc surface. In this case, a longitudinal magnetic recording disc is manufactured. Moreover, by use of, for example, a hexagonal system foundation layer including Ru or Ti, it is possible to cause easy direction of magnetization of the magnetic layer to be oriented along the normal line of the magnetic disc. In this case, a perpendicular magnetic recording disc is manufactured. The foundation layer can be manufactured by sputtering, similarly to the magnetic layer.

[0063] Moreover, in the embodiment of the present invention, a protection layer and a lubrication layer may be sequentially formed by this order on the magnetic layer. For example, the protection layer can be formed by plasma CVD method. As the thickness of the protection layer, between 30 and 80 angstrom is preferable. Further, as the lubrication layer, a

lubrication agent including a functional group at the end of a main chain of perfluoropolyether can be used. Especially, it is preferable that perfluoropolyether including hydroxyl as a polar functional group is used as a main component. The lubrication layer can be formed by application.

[0064] It is especially preferable that a magnetic disc according to the embodiment of the present invention is used as a magnetic disc for a hard disc drive mounted on a mobile device such as a mobile phone, a navigation system, or a digital camera. Moreover, as a glass substrate for a magnetic disc, the glass substrate for a magnetic disc according to the embodiment of the present invention is especially preferable.

[Embodiment]

[0065] Hereinafter, a manufacturing method of a glass substrate for a magnetic disc and a manufacturing method of a magnetic disc will be explained in detail by embodiments.

[0066]

[Embodiment 1]

A manufacturing method of a glass substrate for a magnetic disc according to the Embodiment 1 includes: (1) rough processing step; (2) edge surface mirror polishing step; (3) wrapping step; (4) first polishing step (main surface rough polishing step); (5) cleansing step (cleansing step after rough polishing); (6) second polishing step (main surface mirror polishing step); (7) cleansing step (cleansing step after mirror polishing); and (8) chemical strengthening step. These steps will be explained in detail.

[0067]

(1) Rough processing step

First, a glass disc shaped by press method was polished and processed by a relatively rough diamond grinder. As a glass compound which is a base material, a glass compound including 58 and 75% by weight of SiO_2 , between 5 and 23% by weight of Al_2O_3 , between 3 and 10% by weight of Li_2O , between 4 and 13% by weight of Na_2O , and between 5.5 and 15% by weight of ZrO_2 as main components while ratio by weight of $\text{Na}_2\text{O}/\text{ZrO}_2$ is between 0.5 and 2.0, ratio by weight of $\text{Al}_2\text{O}_3/\text{ZrO}_2$ is between 0.4 and 2.5 was used. This glass compound was a glass which does not include phosphorus oxide or alkaline earth metal oxide such as CaO or MgO . Specifically, N5 glass (brand name) of HOYA Corporation which is amorphous aluminosilicate glass was used.

[0068] Next, by use of a diamond grinder having smaller particle diameter than the above grinder, both sides of the glass disc were polished and processed. Thus, surface roughness of the glass substrate surface was set to 10 μm or so by R_{max} (measured by JISB0601). Next, by use of a cylindrical grinder, a hole was made at the center portion of the disc shaped glass substrate to make a torus shape glass substrate.

[0069]

(2) Edge surface mirror polishing step

Subsequently, by brush polishing, edge surface of the glass substrate was mirror polished while the glass substrate was spinned to have the surface roughness of 1 μm by R_{max} and 0.3 μm by R_a . As an abrasive agent, cerium oxide abrasive agent

was used. Thereafter, surface of the glass substrate was cleaned by water.

[0070]

(3) Wrapping step

Next, wrapping processing was carried out to the glass substrate. The wrapping step is aimed at improving dimensional precision and shape precision. Wrapping processing was carried out by use of a wrapping apparatus and carried out twice, using abrasive agents having particle diameter of #400 and #1000. Specifically, by use of alumina abrasive grain #400 first, causing an internal rotation gear and an outer rotation gear to be rotated, main surfaces of both sides of the glass substrate held in a carrier were wrapped so that the surfaces have a surface accuracy of between 0 and 1 μm and a surface roughness (R_{max}) of 6 μm or so. Then, alumina abrasive grain having a particle diameter of #1000 was used for wrapping to set the surface roughness (R_{max}) to be 2 μm or so. The glass substrate after wrapping processing was sequentially dipped in washing tanks of neutral detergent and water for cleansing.

[0071]

(4) First polishing step (Main surface rough polishing step)

Next, the first polishing step was carried out. The first polishing step was aimed at removing scratch or warp remained in the above-mentioned wrapping step and was carried out by use of a polishing apparatus. Specifically, the first polishing step was carried out by use of a polyurethane hard abrasive pad.

[0072] As an abrasive agent, an abrasive agent including

rare-earth oxide in which content of fluorine is 5% by weight or less, in other words, cerium oxide, as a main component was supplied to the glass substrate and an abrasive cloth and the glass substrate were relatively moved to roughly polish the main surface of the glass substrate. Average particle diameter of the abrasive agent used in the polishing step was 1 μm .

[0073]

(5) Cleansing step (after rough polishing step)

Cleansing step for the glass substrate for a magnetic disc after polishing by use of cerium abrasive agent was carried out. The glass substrate was dipped in a cleansing liquid including ascorbic acid, fluorine ion of between 100 ppm and 1000 ppm, and sulfuric acid of 3% by weight or more to dissolve and remove abrasive agent including rare-earth oxide as a main component. At this time, ultrasonic was also used.

[0074] Moreover, concentration of ascorbic acid and sulfuric acid were fixed, while concentration of fluorine ion was varied between 10 ppm and 1000 ppm, including a comparative example. As a supply source of fluorine ion, hydrofluoric acid (HF) was used and after the cleansing, the substrate was evaluated by use of total X-ray fluorescence (TXRF).

[0075] As a result, results shown in FIG. 1 were obtained. Measurement value of the TXRF is 2.83×10^{10} atoms/cm² when fluorine ion concentration was 200 ppm. Therefore, assuming that one sphere of 1 μm is one particle, it was confirmed that number of abrasive grain included in the abrasive agent having cerium oxide as a main component was 2/cm² or less.

[0076] According to samples 1 to 3 shown in FIG. 1, when concentration of fluorine ion was 200 ppm or more, the abrasive agent "could not be found". Strictly speaking, there existed $2/\text{cm}^2$ of abrasive agent having cerium oxide as a main component as mentioned above, but this is vanishingly small. On the other hand, referring to a comparative example 3 where concentration of fluorine ion was 10 ppm or comparative examples 1 and 2 where silicofluoric acid (H_2SiF_6) was used as a supply source of fluorine ion, measurable level of abrasive agent was detected.

[0077] Thus, it is understood that it is preferable to set concentration of fluorine ion in a range of between 100 and 1000 ppm and more preferably, between 200 and 300 ppm (sample 1 corresponds to this).

[0078]

(6) Second polishing step (Main surface mirror polishing step)

Next, by use of the same polishing apparatus used in the first polishing step, the second polishing step was carried out, changing the abrasive pad from a hard abrasive pad to a soft abrasive pad. Processing carried out in this second polishing step was a mirror polishing processing to finish the main surface to a smooth mirror surface where surface roughness R_{max} was, for example, around 6 nm, while maintaining flat main surface obtained in the above-mentioned first polishing step.

[0079] As abrasive agent, one that includes silica series abrasive grain (colloidal silica) having an average particle diameter of 80 μm , which is smaller than the cerium series abrasive agent in the first polishing step, was used. Abrasive

liquid including such abrasive agent was supplied to the glass substrate and the abrasive pad and the glass substrate were caused to slide to mirror polish the glass substrate surface.

[0080] A soft abrasive pad having hardness of 72 by Ascar C hardness was used as the abrasive pad. Moreover, the surface of the abrasive pad includes foamed polyurethane which has an opening foamed pore.

[0081]

(7) Cleansing step (After mirror polishing step)

Next, cleansing processing of the glass substrate after the second polishing step (main surface mirror polishing step) was carried out as follows. Without drying the glass substrate after the second polishing step, the glass substrate was kept in water and transferred to the next cleansing step in a wet condition. This is because if the glass substrate is dried while polishing residue is remained thereon, there may be a case where it is difficult to remove the residue by the cleansing step.

[0082] This cleansing step was for removing colloidal silica series abrasive agent which remains on the surface of the mirror finished glass substrate in the mirror polishing step. It was required to remove the abrasive agent without damaging the mirror finished glass surface. For example, if the cleansing liquid has an etching effect or leaching effect to the glass, the mirror finished glass surface is damaged and become a pear surface instead of mirror surface. Floating amount of a magnetic head cannot be sufficiently lowered with

the pear surface glass substrate. Therefore, the cleansing liquid must not have an etching or leaching effect to the glass and is composed as a cleansing liquid having selective dissolution property to silica series abrasive agent. That is, the cleansing liquid does not include hydrofluoric acid (HF) or silicofluoric acid (H_2SiF_6) which may cause glass etching.

[0083] Surface roughness Ra of a square area of $5\text{ }\mu\text{m} \times 5\text{ }\mu\text{m}$ on the main surface of the glass substrate after the cleansing processing was measured by an AFM. In five samples, following results were obtained: (1) 0.15 nm, (2) 0.16 nm, (3) 0.18 nm, (4) 0.16 nm, and (5) 0.14 nm. The average value was 0.16 nm. Moreover, when the surface thereof was analyzed by the AFM and an electronic microscope, the surface was mirror surfaced and convex or concave portion was not observed. Residue of the abrasive agent was not detected, too.

[0084]

(8) Chemical strengthening step

Chemical strengthening processing was carried out to the glass substrate after the cleansing step. Chemical strengthening processing is carried out by putting chemical strengthening salt into a chemical strengthening processing tank and dipping the substrate held by a holding member into molten chemical strengthening salt. Specifically, the chemical strengthening processing was carried out by preparing chemical strengthening salt in which potassium nitrate and sodium nitrate are mixed. The chemical salt was heated to 400°C to be molten and the cleansed glass substrate was heated to 300°C .

Then, the glass substrate was dipped into the chemical strengthening salt for about 3 hours. By dipping the glass substrate into the chemical strengthening solution, lithium ion and sodium ion on the surface layer of the glass substrate are replaced by sodium ion and potassium ion in the chemical strengthening solution and the glass substrate is strengthened. Thickness of compression stress layer formed on the surface layer of the glass substrate was about 100 μm . Washing and drying steps for the glass substrate after chemical strengthening processing were sequentially carried out by the order of sulfuric acid cleaning, neutral detergent cleaning, pure water cleaning, alcohol cleaning, and alcohol steam drying.

[0085] When the surface of the glass substrate obtained through the above-mentioned steps was analyzed by the AFM and an electronic microscope, the surface was mirror surfaced and convex or concave portion was not observed. Residue of the abrasive agent was not observed, too. Surface roughness was similar to that after (7) Cleansing step (cleansing step after mirror surface).

[0086] Thus, a glass substrate for a magnetic disc was manufactured.

[0087]

(9) Magnetic disc manufacturing step

A magnetic disc used for perpendicular magnetic recording including at least a foundation layer, a refinement enhancing layer, and a magnetic recording layer on the glass substrate

for a magnetic disc obtained through the above-mentioned steps by this order is manufactured. A granular structured nonmagnetic layer including nonmagnetic substance between crystal grains including cobalt (Co), chromium (Cr), and at least one precious metal element is formed as the refinement enhancing layer. A granular structured nonmagnetic layer including nonmagnetic substance between crystal grains including at least cobalt (Co) is formed as the strong magnetic layer. For the deposition of the magnetic recording layer, sputtering, especially DC magnetron sputtering can be preferably used.

[0088]

[HDD mounting test]

The magnetic disc thus obtained was mounted on a load/unload hard disc drive (HDD) wherein maximum recording density is 60-giga bit per 1 inch². Floating amount of the magnetic head mounted on this hard disc drive is 10 nm and an NPAB slider (negative pressure slider) is used as a slider. A reproduction element is a magnetoresistance effect type reproduction element. When a test was conducted with this hard disc drive, head crash, thermal asperity, or fly stiction did not occur and recording and reproducing could be safely carried out. Operation of load and unload was repeated 600,000 times, but the HDD did not break down.

[0089]

[Reference example]

Next, a reference experiment conducted according to the

embodiment of the present invention will be added.

[0090] Reagent including the same composition as that of the cleansing liquid used in (5) cleansing step (Cleansing step after rough polishing) was made and effect thereof to aluminosilicate glass was researched. Specifically, composition of sulfuric acid and ascorbic acid were same as the cleansing liquid of the embodiment 1 but added amount of fluoric acid was adjusted in various ways to make up reagents including various fluorine ion concentration. This is because fluoric acid is generally used as etching liquid to glass and therefore, it is believed to be better to disclose concentration of fluorine ion which does not prevent the effect of the embodiment of the present invention here.

[0091] Specifically, as shown in FIG. 2, reagents including eight standards for fluorine ion concentration; 1 ppm, 10 ppm, 30 ppm, 100 ppm, 200 ppm, 250 ppm, 300 ppm, and 1000 ppm, were prepared. The reagents were caused to be in contact with an aluminosilicate glass including the same composition as the embodiment 1 to carry out etching and etching speed was researched. As a result, when the concentration of fluorine ion was 10 ppm or less, average value of etching speed was 0.03nm/min or slower, which means that etching does not occur substantially. When the concentration was 30 ppm, the average value increased to 0.7 nm/min and when the concentration was 100 ppm, the average value of etching speed suddenly increased to 0.54nm/min. However, because cutting stock in the mirror polishing step is larger than this and is between 0.25 μm and

several μm or so on one side and therefore, it can be judged that fluorine ion concentration of 100 ppm is useful for the embodiment of the present invention and the concentration may be increased up to 1000 ppm.

[0092] Meanwhile, as shown in FIG. 2, targeted etching speed is 3.64 nm/min and therefore, to fulfill the targeted etching speed, at least 200 ppm of fluorine ion concentration is required. Therefore, as mentioned above, fluorine concentration of between 200 and 300 ppm is the most economical and recommended fluorine concentration.

[0093]

[Embodiment 2]

Next, in the embodiment 1, after chemical strengthening step and before magnetic disc manufacturing step, a glass substrate for a magnetic disc and a magnetic disc to which tape polishing processing was carried out were manufactured. By carrying out the tape polishing processing on the surface of the disc shaped glass substrate, a texture including a line oriented in the circumferential direction of the disc was formed. Specifically, on the surface of a disc shaped glass substrate which was chemically strengthened, a polishing tape including woven fabric of resin fibre was caused to be contacted and while diamond abrasive grain was supplied, glass substrate was spinned to form a fine texture on the surface of the glass substrate. When the surface of the glass substrate after the texture forming processing was observed by an AFM, surface roughness was similar to that of embodiment 1 but on the surface

of the glass substrate, a fine texture was formed. A line of the texture oriented in the circumferential direction of the disc. Convex or concave portion or a damage formed by biting of a foreign matter which damages the texture could not be found. On this glass substrate, deposition was conducted as in the embodiment 1 to manufacture a magnetic disc.

[0094] However, the first foundation layer was replaced by a CrTa foundation layer, the second foundation layer was replaced by a AlRu foundation layer, and a CrMo foundation layer was inserted between the second foundation layer and the magnetic layer as a third foundation layer.

[0095] Thus, a longitudinal recording magnetic disc was manufactured. Except these points, manufactured are the same as the glass substrate for a magnetic disc and a magnetic disc by the same manufacturing method as the embodiment 1.

[0096] When HDD mounting test of the obtained magnetic disc was conducted, suitable result as the embodiment 1 was obtained. Next, magnetic anisotropy of the magnetic disc was researched. Specifically, coercive force in circumferential direction of the magnetic disc (H_{c1}) and that in radial direction (H_{c2}) were measured and H_{c1}/H_{c2} was evaluated as magnetic anisotropic index (OR). Magnetic property assessment procedure by a vibration sample magnetometer (VSM) was used to measure the coercive force. At this time, maximum applied external magnetic field was set to 8-kiloersted. As a result, OR was given around 1.2. That is, in this magnetic disc, magnetic property (in this case, coercive force) in circumferential

direction excels that in radial direction by 20%.

[0097] A preferred embodiment of the present invention was explained with reference to attached figures. However, it is needless to say that the present invention is not limited to this example. As will be understood by the skilled persons, various modifications and variations of the present invention are possible in the light of the scope of the subjoined claims and therefore all the modifications and variations fall within the technical scope of the present invention.

[0098]

The present invention can be applied to a manufacturing method of a glass substrate for a magnetic disc and a manufacturing method of a magnetic disc mounted on a magnetic disc device such as a hard disc drive.

What is claimed is:

1. A manufacturing method of a glass substrate for a magnetic disc, comprising:

a rough polishing step for roughly polishing a main surface of a glass substrate;

a mirror polishing step for mirror polishing the main surface of the glass substrate after the rough polishing step; and

a cleansing step for cleansing the glass substrate between the rough polishing step and the mirror polishing step,

wherein in the rough polishing step, abrasive agent including rare-earth oxide in which content of fluorine is 5% by weight or less as a main component is supplied to the glass substrate and an abrasive cloth and the glass substrate are relatively moved to roughly polish the main surface of the glass substrate;

wherein in the mirror polishing step, abrasive agent which is different from one including rare-earth oxide as a main composition is supplied to the glass substrate and an abrasive cloth and the glass substrate are relatively moved to mirror polish the main surface of the glass substrate; and

wherein in the cleansing step, the abrasive agent including rare-earth oxide as a main composition is molten and removed and the glass substrate main surface is etching processed with a cutting stock smaller than the cutting stock of the glass substrate main surface in the mirror polishing

step.

2. A manufacturing method of a glass substrate for a magnetic disc, comprising:

a rough polishing step for roughly polishing a main surface of a glass substrate;

a mirror polishing step for mirror polishing the main surface of the glass substrate after the rough polishing step by use of an abrasive agent which is a different abrasive agent from that used in the rough polishing step; and

a cleansing step for cleansing the glass substrate between the rough polishing step and the mirror polishing step,

wherein in the rough polishing step, abrasive agent including rare-earth oxide in which content of fluorine is 5% by weight or less of as a main component is supplied to the glass substrate and an abrasive cloth and the glass substrate are relatively moved to roughly polish the main surface of the glass substrate;

wherein in the cleansing step, the glass substrate is caused to come into contact with a cleansing liquid includes ascorbic acid, 100 ppm or more and 1000 ppm or less fluorine ion, and sulfuric acid of 3% by weight or more to remove by dissolving the abrasive agent including rare-earth oxide as a main composition.

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

wherein in the cleansing step, abrasive agent including rare-earth oxide as a main component is removed by dissolution so that the number of abrasive grains included in the abrasive agent including rare-earth oxide as a main component existing on the main surface of the glass substrate becomes $2/\text{cm}^2$.

4. A manufacturing method of a magnetic disc,

wherein at least a magnetic layer is formed on a glass substrate manufactured by the method according to any of claims 1 to 3.