Oxygen deficit is caused in yttrium-contained partially stabilized zirconia, and chemical reactions are accordingly easily caused between zirconium contained in partially stabilized zirconia and oxygen in silicon dioxide (SiO_2) in the glass substrate surface. Accordingly, silicon in silicon dioxide is easily separated from the glass substrate surface.

[0018]

As described above, deep scratches are not easily produced, and thereby, a removal stock is not increased in the post polishing step (i.e., a second polishing step). Therefore, the edge of a principal face of a glass substrate is not easily rounded. Incidentally, the edge of a glass substrate tends to be rounded when abrasive grains are fractured during polishing and the number of minute particles is thereby increased. However, in yttrium-contained partially stabilized zirconia, fracturing of abrasive grains is not easily caused as described above, and therefore, the edge is not easily rounded.

[0019]

Based on the above, a second aspect of the present invention relates to a manufacturing method of a glass substrate for a magnetic disk including a polishing step of executing polishing using a slurry containing yttrium-contained partially stabilized zirconia as an abrasive.

[0020]

In the aforementioned manufacturing method of a glass substrate for a magnetic disk according to the second aspect, the abrasive preferably contains yttrium oxide in a range of 1 to 6 % by mole.

[0021]

In the aforementioned manufacturing method of a glass substrate for a magnetic disk according to the second aspect, cubic crystalline structures preferably show the highest peak of diffraction intensity among crystalline structures of zirconia in a diffraction pattern, which is obtained by conducting x-ray powder diffraction for the abrasive, of representing a relation between incident angle and diffraction intensity.

[0022]

In the aforementioned manufacturing method of a glass substrate for a magnetic disk, the glass substrate is preferably made of glass having the fracture toughness value in a range of 0.4 to 1.5 $MPa/m^{1/2}$.

[0023]

In the aforementioned manufacturing method of a glass substrate for a magnetic disk, the average particle size D50 of the zirconium oxide abrasive grains is preferably set to be in a range of 0.2 to 0.5 μm.

[0024]

In the aforementioned manufacturing method of a glass substrate for a magnetic disk, a

Ni_2O_3, Nb_2O_5, MoO_3, SnO_2, CeO_2, Ta_2O_5, and Bi_2O_3, it is more preferable to set the mole fraction of the total amount of the multivalent element oxide relative to CaO (total amount of the multivalent element oxide divided by CaO) to be greater than or equal to 0.25. Setting the mole fraction as above, air bubbles in the glass can be sufficiently removed.

Furthermore, it is more preferable that the aforementioned multivalent element oxide contains at least one of multivalent elements selected from the group of V, Mn, Sn, and Ce. V, Mn, Sn, and Ce are particularly preferable for removing air bubbles effectively.

[0036]

As will be described later, in the manufacturing method of a glass substrate for a magnetic disk according to the present exemplary embodiment, a polishing step of polishing a principal face of the glass substrate using a slurry containing zirconium oxide abrasive grains having monoclinic crystalline structures and tetragonal crystalline structures as an abrasive. Hardness of the glass substrate having the aforementioned glass composition is suitable for such the abrasive as above. In other words, the polishing rate can be high while nano pits or nano scratches produced on the principal face of the glass substrate are suppressed in the polishing step.

It should be noted that amorphous aluminosilicate glass is more preferable to be used because the structure of the amorphous aluminosilicate glass is uniform since it has no crystal structure such as crystallized glass. Therefore, the extremely smooth surface can be obtained.

[0037]

Furthermore, with respect to the glass substrate of the present exemplary embodiment, it is preferable to set the fracture toughness value K_{1c} to be 0.4 to 1.5 [$MPa/m^{1/2}$] in Vickers hardness testing. It is more preferable to set to be 0.5 to 1.0 [$MPa/m^{1/2}$]. When a glass composition having the fracture toughness value in this range is used, nano pits or nano scratches produced on a principal face of the glass substrate can be reduced while the polishing rate is well maintained in the polishing step using the abrasive.

Here, the fracture toughness value K_{1c} can be measured by a method in which a sharp diamond indenter of a well-known Vickers hardness tester is pressed into a glass plate. Specifically, the fracture toughness value K_{1c} can be calculated by the following formula based on the size of an indent which is made when the Vickers diamond indenter is pressed into the glass plate and the length of a crack caused from a corner of the indent. In the formula, P represents a pressing load [N] of the Vickers diamond indenter, a represents half the length of the diagonal line [m] of the Vickers indent, E represents Young's modulus [Pa] of the glass plate, and C represents half the length of a crack.

[0038]

adhesive layer, an underlying layer, a magnetic layer (magnetic recording layer), a protective layer and a wetting layer, are sequentially laminated in this order from bottom to top on a principal face of a magnetic disk glass substrate (hereinafter simply referred to as "a substrate").

For example, the substrate is introduced into a vacuumed film forming device, and the adhesive layer, the underlying layer and the magnetic layer are sequentially formed atop the principal face of the substrate in an Ar atmosphere by means of DC magnetron spattering. For example, CrTi may be used as the adhesive layer, while CrRu may be used as the underlying layer. For example, CoPt alloy may be used as the magnetic layer. Alternatively, CoPt alloy or FePt alloy, having the L10 ordered structure, may be formed as the magnetic layer for heat assisted magnetic recording. After the formation of the layers, the protective layer is formed, for instance, using C_2H_4 by means of a CVD method. Next, a nitriding treatment is executed by introducing nitrogen into the surface. Accordingly, the magnetic recording medium can be formed. Subsequently, the wetting layer can be formed by applying e.g., PFPE (perfluoropolyether) onto the protective layer by means of a dip coating method.

The fabricated magnetic disk, together with a magnetic head embedded with a DFH (Dynamic Flying Height) Control mechanism, is preferably installed in a HDD (Hard Disk Drive) as a magnetic recording/reproducing device.

[0068]

<Second Exemplary Embodiment>

A manufacturing method of a glass substrate for a magnetic disk according to a second exemplary embodiment will be hereinafter explained. A magnetic disk glass substrate to be manufactured by the manufacturing method of the present exemplary embodiment is the same as that manufactured in the first exemplary embodiment. Further, the manufacturing method of the present exemplary embodiment is different from that of the first exemplary embodiment regarding the abrasive contained in the slurry to be used in the first polishing (principal face polishing) step.

It should be noted that a fracture toughness valueK_{1c} of the glass substrate is preferably set to be 0.4 to 1.5 [$Mpa/m^{1/2}$], and more pereferably set to be 0.5 to 1.0 in Vickers hardness testing in the present exemplary embodiment.

[0069]

In the present exemplary embodiment, the slurry to be used for the polisher device of FIG. 1 contains, as the abrasive, abrasive grains of partially stabilized zirconia (hereinafter referred to as "yttrium-contained zirconia") that contains either yttrium or yttrium oxide as a stabilizing agent. The slurry can be prepared as follows. First, an appropriate amount of water, and further arbitrarily, additives (e.g., a dispersant, a re-aggregation inhibitor, a pH adjustor, an electric charge modifier, a

the fracture toughness value of 0.7 [MPa/m$^{1/2}$]. Specifically, the glass was prepared to have a composition containing 64.1 % by weight of SiO_2, 14.7 % by weight ofAl_2O_3, 3.6 % by weight of Li_2O, 11.1 % by weight of Na_2O, 0.4 % by weight of K_2O, 0.6% by weight of MgO, 2.0 % by weight of ZrO_2, and 1.6 % by weight of CaO. 1.9 % by weight of Nb_2O_5 was also contained as clarifying agent.

[0077]

(2) Fabrication of Glass Substrate

The aforementioned molten glass, clarified and homogenized, was poured from the pipe(s) onto a bottom mold for press-molding at a predetermined flow rate. The poured molten glass was then cut by a cutting blade for obtaining a predetermined amount of molten glass gob onto the bottom mold. The bottom mold with the molten glass gob disposed thereon was immediately transported from the position below the pipe(s) to a predetermined position. The molten glass gob disposed on the bottom mold was press-molded in a thin disc shape using a top mold opposed to the bottom mold and a barrel. The press-molded product was cooled down to a temperature not causing deformation of the press-molded product. The cooled press-molded product was removed out of the molds, and was then annealed to obtain a glass blank of amorphous. Subsequently, a lapping processing was executed for the glass blank obtained by the press-molding. In the lapping processing, alumina abrasive grains (a particle size of #1000) were used as loose abrasive grains.

[0078]

(3) Coring and Chamfering

An inner hole was formed in the center part of the disc-shaped glass material using a cylindrical diamond drill for obtaining an annular glass substrate (i.e., coring). Then, the inner and outer peripheral edges of the annular glass substrate were ground by means of a diamond abrasive block for executing a predetermined chamfering processing (i.e., chamfering).

[0079]

(4) Edge polishing Step

Next, mirror polishing was executed for the edges of the annular glass substrate by means of a brush polishing method. Slurry (loose abrasive grains), containing cerium oxide abrasive grains, was herein used as the polishing abrasive grains. Through the edge polishing step, the edges of the glass substrate were processed in a mirror surface state for preventing the raising of dust such as particles.

Through the aforementioned processing, the annular glass substrate with an outer diameter of 65 mm, an inner diameter of 20 mm and a thickness of 0.8 mm was obtained as a polishing target.

[0080]

- Polishing load: 100 g/cm^2
- Platen rotational speed: 30 rpm
- Removal stock (total of front and back surfaces): 30 μm

Polishing device: Device similar to the device used in the first polishing step

[0094]

Different types of glass substrates were fabricated to have varied fracture toughness values of glass respectively by adjusting each glass composition. Specifically, the fracture toughness values of the glass substrates were 0.2, 0.4, 0.5, 1.0, 1.5, and 2.0 [MPa/m$^{1/2}$], respectively. The glass substrates were used for the first polishing with respect to the principal faces of the glass substrates. The polishing was executed under the same condition as in the practical example 2. The fracture toughness value was measured with a Vickers hardness tester.

When the glass substrates having the fracture toughness value of 0.2 and 2.0 [MPa/m$^{1/2}$] respectively were used, the polishing rate and existence of nano pits and/or nano scratches were almost the same degree as in the practical example 2. The degree of the polishing rate and existence of nano pits and/or nano scratches was higher than that of the practical example 2 when the fracture toughness value was 0.4 or 1.5 [MPa/m$^{1/2}$]. Moreover, the degree of the polishing rate and existence of nano pits and/or nano scratches was even higher when the fracture toughness value was 0.5 or 1.0 [MPa/m$^{1/2}$].

[0095]

A magnetic disk was fabricated by forming a magnetic layer on a glass substrate for a magnetic disk obtained in the practical examples 1 to 6. Subsequently, the magnetic disk was assembled to a hard disk drive (HDD) having a rotational speed of 7200 rpm. Then, a certify test (recording/reproducing test of magnetic signal) was conducted while a DFH mechanism of a head was employed with the HDD. As a result of the test, an error was not occurred.

[0096]

(5-2) Comparative Example and Practical Examples Represented in Table 2

In Table 2, an abrasive of a comparative example was fabricated by fracturing zirconia not containing a stabilizing agent. On the other hand, abrasives of practical examples are yttrium-contained zirconia, and the contained amount of yttrium is expressed by mole ratio (a ratio of Y_2O_3 with respect to (Y_2O_3+ZrO_2)) where yttrium is converted at yttria (Y_2O_3).

In the comparative example and the practical examples, average (D50) and standard deviation (SD) of the particle sizes of abrasive grains of an abrasive were approximately matched. Specifically, the average (D50) of the particle sizes was set to be in a range of 0.2 to 0.5 [μm], while the standard deviation (SD) was set to be in a range of 0.05 to 0.15 [μm]. More specifically, the

zirconium abrasive and the second polishing step using colloidal silica abrasive grains. When cerium oxide abrasive grains are used as an abrasive, the edge shape is easy to be a ski jump shape, thereby the Dub-off value can be lowered. It should be noted that the polishing step using the cerium oxide abrasive grains is preferably executed before a chemically strengthening step in order to maintain a large amount of compression stress layer formed on the principal face of the glass substrate by means of the chemically strengthening step.

[0105]

An intermediate polishing step using cerium oxide abrasive grains, a chemically strengthening step, and a final polishing step (a post polishing step) were executed in this order with respect to the glass substrate in the practical example 8. In the intermediate polishing step, a slurry prepared by mixing 10 % by weight of cerium oxide abrasive grains having a particle size of 1.0 μm into water, was used to polish a principal face of the glass substrate under the conditions as follows. As a result, a Dub-off value of the glass substrate after executing the final polishing step using colloidal silica as polishing abrasive grains was less than or equal to 5 nm, which is a remarkably good result.

<Polishing Conditions>

- Polisher pad: Suede pad made of formed polyurethane (JIS-A hardness: 85)
- Polishing load: 100 g/cm2
- Platen rotational speed: 30 rpm
- Removal stock (total of front and back surfaces): 30 μm
- Polishing device: Device similar to the device used in the first polishing step

[0106]

Different types of glass substrates were fabricated to have varied fracture toughness values of glass respectively by adjusting each glass composition. Specifically, the fracture toughness values of the glass substrates are 0.2, 0.4, 0.5, 1.0, 1.5, and 2.0 [MPa/m$^{1/2}$], respectively. The glass substrates were used for the first polishing with respect to the principal faces of the glass substrates. The polishing was executed under the same condition as in the practical example 8. The fracture toughness value was measured with a Vickers hardness tester.

When the glass substrates having the fracture toughness value of 0.2 and 2.0 [MPa/m$^{1/2}$] respectively were used, the polishing speed, flaws, and an edge shape were almost the same degree as in the practical example 2. The degree of the polishing speed, flaws, and an edge shape was higher than that of the practical example 8 when the fracture toughness value was 0.4 or 1.5 [MPa/m$^{1/2}$]. Moreover, the degree the polishing speed, flaws, and an edge shape was even higher when the fracture toughness value was 0.5 or 1.0 [MPa/m$^{1/2}$].

[0107]

What is claimed is:

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

a polishing step of polishing a principal face of the glass substrate using a slurry containing zirconium oxide abrasive grains having monoclinic crystalline structures and tetragonal crystalline structures as an abrasive.

2. The manufacturing method of a glass substrate for a magnetic disk recited in claim 1, wherein in the zirconium oxide abrasive grains, a ratio of the amount of the tetragonal crystalline structures with respect to the amount of the monoclinic crystalline structures falls in a range of 0.7 % to 3.0 %. (where the ratio is obtained by means of x-ray diffraction and is defined as a ratio of a peak intensity of the tetragonal crystalline structures with respect to a peak intensity of the monoclinic crystalline structures; and the peak intensity is herein defined as an integrated peak intensity.)

3. The manufacturing method of a glass substrate for a magnetic disk recited in claim 1 or claim 2, wherein the zirconium oxide abrasive grains are made of aggregates of primary particles of zirconium oxide and the primary particles of zirconium oxide have both the monoclinic crystalline structures and the tetragonal crystalline structures.

4. The manufacturing method of a glass substrate for a magnetic disk recited in any of claims 1 to 3, wherein the zirconium oxide abrasive grains do not contain stabilizing agent.

5. The manufacturing method of a glass substrate for a magnetic disk recited in any of claims 1 to 4 wherein the average particle size D50 of the zirconium oxide abrasive grains is set to be in a range of 0.2 to 0.5 μm.

6. The manufacturing method of a glass substrate for a magnetic disk recited in any of claims 1 to 5, wherein a polisher pad is used for polishing a principal face of the glass substrate in the polishing step, the polisher pad having hardness in a range of 80 to 100 in JIS-A hardness.

7. A manufacturing method of a glass substrate for a magnetic disk, comprising:

a polishing step of executing polishing using a slurry containing yttrium-contained partially stabilized zirconia as an abrasive.

8. The manufacturing method of a glass substrate for a magnetic disk recited in claim 7, wherein the abrasive contains yttrium in a range of 1 to 6 % by mole.

9. The manufacturing method of a glass substrate for a magnetic disk recited in claim 8, wherein the abrasive contains yttrium oxide in a range of 1 to 6 % by mole.

10. The manufacturing method of a glass substrate for a magnetic disk recited in any of claims 1 to 9, wherein the glass substrate is made of glass, the glass having the fracture toughness value in a range of 0.4 to 1.5 $MPa/m^{1/2}$.

11. The manufacturing method of a glass substrate for a magnetic disk recited in any of claims 1 to 10, further comprising:

a post polishing step of polishing using a slurry containing colloidal silica as abrasive grains , the post polishing step configured to be executed after the polishing step.

12 The manufacturing method of a glass substrate for a magnetic disk recited in claim 11, wherein a removal stock is set to be less than or equal to 5 μm in the post polishing step.

13. The manufacturing method of a glass substrate for a magnetic disk recited in claim 11 or claim 12, further comprising:

an intermediate polishing step of polishing using a slurry containing cerium oxide abrasive grains, the intermediate polishing step being executed between the polishing step and the post polishing step.

14. The manufacturing method of a glass substrate for a magnetic disk recited in any of claims 11 to claim 13, further comprising:

a chemically strengthening step configured to be executed between the polishing step and the post polishing step.

15. A magnetic disk made of a glass substrate manufactured with the method recited in any of claims 1 to 13, wherein at least a magnetic layer is formed on a principal face of the glass substrate.

16. A magnetic recording/reproducing device, comprising:

the magnetic disk recited in claim 15; and

a magnetic head embedded with a DFH (Dynamic Flying Height) control mechanism.

Oxygen deficit is caused in yttrium-contained partially stabilized zirconia, and chemical reactions are accordingly easily caused between zirconium contained in partially stabilized zirconia and oxygen in silicon dioxide (SiO_2) in the glass substrate surface. Accordingly, silicon in silicon dioxide is easily separated from the glass substrate surface.

[0018]

As described above, deep scratches are not easily produced, and thereby, a removal stock is not increased in the post polishing step (i.e., a second polishing step). Therefore, the edge of a principal face of a glass substrate is not easily rounded. Incidentally, the edge of a glass substrate tends to be rounded when abrasive grains are fractured during polishing and the number of minute particles is thereby increased. However, in yttrium-contained partially stabilized zirconia, fracturing of abrasive grains is not easily caused as described above, and therefore, the edge is not easily rounded.

[0019]

Based on the above, a second aspect of the present invention relates to a manufacturing method of a glass substrate for a magnetic disk including a polishing step of executing polishing using a slurry containing yttrium-contained partially stabilized zirconia as an abrasive.

[0020]

In the aforementioned manufacturing method of a glass substrate for a magnetic disk according to the second aspect, the abrasive preferably contains yttrium oxide in a range of 1 to 6 % by mole.

[0021]

In the aforementioned manufacturing method of a glass substrate for a magnetic disk according to the second aspect, cubic crystalline structures preferably show the highest peak of diffraction intensity among crystalline structures of zirconia in a diffraction pattern, which is obtained by conducting x-ray powder diffraction for the abrasive, of representing a relation between incident angle and diffraction intensity.

[0022]

In the aforementioned manufacturing method of a glass substrate for a magnetic disk, the glass substrate is preferably made of glass having the fracture toughness value in a range of 0.4 to 1.5 $MPa \cdot m^{1/2}$.

[0023]

In the aforementioned manufacturing method of a glass substrate for a magnetic disk, the average particle size D50 of the zirconium oxide abrasive grains is preferably set to be in a range of 0.2 to 0.5 μm.

[0024]

In the aforementioned manufacturing method of a glass substrate for a magnetic disk, a

Ni_2O_3, Nb_2O_5, MoO_3, SnO_2, CeO_2, Ta_2O_5, and Bi_2O_3, it is more preferable to set the mole fraction of the total amount of the multivalent element oxide relative to CaO (total amount of the multivalent element oxide divided by CaO) to be greater than or equal to 0.25. Setting the mole fraction as above, air bubbles in the glass can be sufficiently removed.

Furthermore, it is more preferable that the aforementioned multivalent element oxide contains at least one of multivalent elements selected from the group of V, Mn, Sn, and Ce. V, Mn, Sn, and Ce are particularly preferable for removing air bubbles effectively.

[0036]

As will be described later, in the manufacturing method of a glass substrate for a magnetic disk according to the present exemplary embodiment, a polishing step of polishing a principal face of the glass substrate using a slurry containing zirconium oxide abrasive grains having monoclinic crystalline structures and tetragonal crystalline structures as an abrasive. Hardness of the glass substrate having the aforementioned glass composition is suitable for such the abrasive as above. In other words, the polishing rate can be high while nano pits or nano scratches produced on the principal face of the glass substrate are suppressed in the polishing step.

It should be noted that amorphous aluminosilicate glass is more preferable to be used because the structure of the amorphous aluminosilicate glass is uniform since it has no crystal structure such as crystallized glass. Therefore, the extremely smooth surface can be obtained.

[0037]

Furthermore, with respect to the glass substrate of the present exemplary embodiment, it is preferable to set the fracture toughness value K_{1c} to be 0.4 to 1.5 [$MPa \cdot m^{1/2}$] in Vickers hardness testing. It is more preferable to set to be 0.5 to 1.0 [$MPa \cdot m^{1/2}$]. When a glass composition having the fracture toughness value in this range is used, nano pits or nano scratches produced on a principal face of the glass substrate can be reduced while the polishing rate is well maintained in the polishing step using the abrasive.

Here, the fracture toughness value K_{1c} can be measured by a method in which a sharp diamond indenter of a well-known Vickers hardness tester is pressed into a glass plate. Specifically, the fracture toughness value K_{1c} can be calculated by the following formula based on the size of an indent which is made when the Vickers diamond indenter is pressed into the glass plate and the length of a crack caused from a corner of the indent. In the formula, P represents a pressing load [N] of the Vickers diamond indenter, a represents half the length of the diagonal line [m] of the Vickers indent, E represents Young's modulus [Pa] of the glass plate, and C represents half the length of a crack.

[0038]

adhesive layer, an underlying layer, a magnetic layer (magnetic recording layer), a protective layer and a wetting layer, are sequentially laminated in this order from bottom to top on a principal face of a magnetic disk glass substrate (hereinafter simply referred to as "a substrate").

For example, the substrate is introduced into a vacuumed film forming device, and the adhesive layer, the underlying layer and the magnetic layer are sequentially formed atop the principal face of the substrate in an Ar atmosphere by means of DC magnetron spattering. For example, CrTi may be used as the adhesive layer, while CrRu may be used as the underlying layer. For example, CoPt alloy may be used as the magnetic layer. Alternatively, CoPt alloy or FePt alloy, having the L10 ordered structure, may be formed as the magnetic layer for heat assisted magnetic recording. After the formation of the layers, the protective layer is formed, for instance, using C_2H_4 by means of a CVD method. Next, a nitriding treatment is executed by introducing nitrogen into the surface. Accordingly, the magnetic recording medium can be formed. Subsequently, the wetting layer can be formed by applying e.g., PFPE (perfluoropolyether) onto the protective layer by means of a dip coating method.

The fabricated magnetic disk, together with a magnetic head embedded with a DFH (Dynamic Flying Height) Control mechanism, is preferably installed in a HDD (Hard Disk Drive) as a magnetic recording/reproducing device.

[0068]

<Second Exemplary Embodiment>

A manufacturing method of a glass substrate for a magnetic disk according to a second exemplary embodiment will be hereinafter explained. A magnetic disk glass substrate to be manufactured by the manufacturing method of the present exemplary embodiment is the same as that manufactured in the first exemplary embodiment. Further, the manufacturing method of the present exemplary embodiment is different from that of the first exemplary embodiment regarding the abrasive contained in the slurry to be used in the first polishing (principal face polishing) step.

It should be noted that a fracture toughness valueK_{1c} of the glass substrate is preferably set to be 0.4 to 1.5 [$MPa \cdot m^{1/2}$], and more pereferably set to be 0.5 to 1.0 in Vickers hardness testing in the present exemplary embodiment.

[0069]

In the present exemplary embodiment, the slurry to be used for the polisher device of FIG. 1 contains, as the abrasive, abrasive grains of partially stabilized zirconia (hereinafter referred to as "yttrium-contained zirconia") that contains either yttrium or yttrium oxide as a stabilizing agent. The slurry can be prepared as follows. First, an appropriate amount of water, and further arbitrarily, additives (e.g., a dispersant, a re-aggregation inhibitor, a pH adjustor, an electric charge modifier, a

the fracture toughness value of 0.7 [MPa·$m^{1/2}$]. Specifically, the glass was prepared to have a composition containing 64.1 % by weight of SiO_2, 14.7 % by weight ofAl_2O_3, 3.6 % by weight of Li_2O, 11.1 % by weight of Na_2O, 0.4 % by weight of K_2O, 0.6% by weight of MgO, 2.0 % by weight of ZrO_2, and 1.6 % by weight of CaO. 1.9 % by weight of Nb_2O_5 was also contained as clarifying agent.

[0077]

(2) Fabrication of Glass Substrate

The aforementioned molten glass, clarified and homogenized, was poured from the pipe(s) onto a bottom mold for press-molding at a predetermined flow rate. The poured molten glass was then cut by a cutting blade for obtaining a predetermined amount of molten glass gob onto the bottom mold. The bottom mold with the molten glass gob disposed thereon was immediately transported from the position below the pipe(s) to a predetermined position. The molten glass gob disposed on the bottom mold was press-molded in a thin disc shape using a top mold opposed to the bottom mold and a barrel. The press-molded product was cooled down to a temperature not causing deformation of the press-molded product. The cooled press-molded product was removed out of the molds, and was then annealed to obtain a glass blank of amorphous. Subsequently, a lapping processing was executed for the glass blank obtained by the press-molding. In the lapping processing, alumina abrasive grains (a particle size of #1000) were used as loose abrasive grains.

[0078]

(3) Coring and Chamfering

An inner hole was formed in the center part of the disc-shaped glass material using a cylindrical diamond drill for obtaining an annular glass substrate (i.e., coring). Then, the inner and outer peripheral edges of the annular glass substrate were ground by means of a diamond abrasive block for executing a predetermined chamfering processing (i.e., chamfering).

[0079]

(4) Edge polishing Step

Next, mirror polishing was executed for the edges of the annular glass substrate by means of a brush polishing method. Slurry (loose abrasive grains), containing cerium oxide abrasive grains, was herein used as the polishing abrasive grains. Through the edge polishing step, the edges of the glass substrate were processed in a mirror surface state for preventing the raising of dust such as particles.

Through the aforementioned processing, the annular glass substrate with an outer diameter of 65 mm, an inner diameter of 20 mm and a thickness of 0.8 mm was obtained as a polishing target.

[0080]

- Polishing load: 100 g/cm^2
- Platen rotational speed: 30 rpm
- Removal stock (total of front and back surfaces): 30 μm

Polishing device: Device similar to the device used in the first polishing step

[0094]

Different types of glass substrates were fabricated to have varied fracture toughness values of glass respectively by adjusting each glass composition. Specifically, the fracture toughness values of the glass substrates were 0.2, 0.4, 0.5, 1.0, 1.5, and 2.0 [MPa·m$^{1/2}$], respectively. The glass substrates were used for the first polishing with respect to the principal faces of the glass substrates. The polishing was executed under the same condition as in the practical example 2. The fracture toughness value was measured with a Vickers hardness tester.

When the glass substrates having the fracture toughness value of 0.2 and 2.0 [MPa·m$^{1/2}$] respectively were used, the polishing rate and existence of nano pits and/or nano scratches were almost the same degree as in the practical example 2. The degree of the polishing rate and existence of nano pits and/or nano scratches was higher than that of the practical example 2 when the fracture toughness value was 0.4 or 1.5 [MPa·m$^{1/2}$]. Moreover, the degree of the polishing rate and existence of nano pits and/or nano scratches was even higher when the fracture toughness value was 0.5 or 1.0 [MPa·m$^{1/2}$].

[0095]

A magnetic disk was fabricated by forming a magnetic layer on a glass substrate for a magnetic disk obtained in the practical examples 1 to 6. Subsequently, the magnetic disk was assembled to a hard disk drive (HDD) having a rotational speed of 7200 rpm. Then, a certify test (recording/reproducing test of magnetic signal) was conducted while a DFH mechanism of a head was employed with the HDD. As a result of the test, an error was not occurred.

[0096]

(5-2) Comparative Example and Practical Examples Represented in Table 2

In Table 2, an abrasive of a comparative example was fabricated by fracturing zirconia not containing a stabilizing agent. On the other hand, abrasives of practical examples are yttrium-contained zirconia, and the contained amount of yttrium is expressed by mole ratio (a ratio of Y_2O_3 with respect to (Y_2O_3+ZrO_2)) where yttrium is converted at yttria (Y_2O_3).

In the comparative example and the practical examples, average (D50) and standard deviation (SD) of the particle sizes of abrasive grains of an abrasive were approximately matched. Specifically, the average (D50) of the particle sizes was set to be in a range of 0.2 to 0.5 [μm], while the standard deviation (SD) was set to be in a range of 0.05 to 0.15 [μm]. More specifically, the

zirconium abrasive and the second polishing step using colloidal silica abrasive grains. When cerium oxide abrasive grains are used as an abrasive, the edge shape is easy to be a ski jump shape, thereby the Dub-off value can be lowered. It should be noted that the polishing step using the cerium oxide abrasive grains is preferably executed before a chemically strengthening step in order to maintain a large amount of compression stress layer formed on the principal face of the glass substrate by means of the chemically strengthening step.

[0105]

An intermediate polishing step using cerium oxide abrasive grains, a chemically strengthening step, and a final polishing step (a post polishing step) were executed in this order with respect to the glass substrate in the practical example 8. In the intermediate polishing step, a slurry prepared by mixing 10 % by weight of cerium oxide abrasive grains having a particle size of 1.0 μm into water, was used to polish a principal face of the glass substrate under the conditions as follows. As a result, a Dub-off value of the glass substrate after executing the final polishing step using colloidal silica as polishing abrasive grains was less than or equal to 5 nm, which is a remarkably good result.

<Polishing Conditions>

- Polisher pad: Suede pad made of formed polyurethane (JIS-A hardness: 85)
- Polishing load: 100 g/cm2
- Platen rotational speed: 30 rpm
- Removal stock (total of front and back surfaces): 30 μm
- Polishing device: Device similar to the device used in the first polishing step

[0106]

Different types of glass substrates were fabricated to have varied fracture toughness values of glass respectively by adjusting each glass composition. Specifically, the fracture toughness values of the glass substrates are 0.2, 0.4, 0.5, 1.0, 1.5, and 2.0 [$MPa \cdot m^{1/2}$], respectively. The glass substrates were used for the first polishing with respect to the principal faces of the glass substrates. The polishing was executed under the same condition as in the practical example 8. The fracture toughness value was measured with a Vickers hardness tester.

When the glass substrates having the fracture toughness value of 0.2 and 2.0 [$MPa \cdot m^{1/2}$] respectively were used, the polishing speed, flaws, and an edge shape were almost the same degree as in the practical example 2. The degree of the polishing speed, flaws, and an edge shape was higher than that of the practical example 8 when the fracture toughness value was 0.4 or 1.5 [$MPa \cdot m^{1/2}$]. Moreover, the degree the polishing speed, flaws, and an edge shape was even higher when the fracture toughness value was 0.5 or 1.0 [$MPa \cdot m^{1/2}$].

[0107]

What is claimed is:

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

a polishing step of polishing a principal face of the glass substrate using a slurry containing zirconium oxide abrasive grains, each of the abrasive grains having zirconium oxide as a principal component, with the zirconium oxide in each of the abrasive grains having crystallites of monoclinic crystalline structures and crystallites of tetragonal crystalline structures as an abrasive, and in each of the zirconium oxide abrasive grains, a ratio of the amount of the tetragonal crystalline structures with respect to the amount of the monoclinic crystalline structures falls in a range of 0.7 % to 3.0 %, where the ratio is obtained by x-ray diffraction and is defined as a ratio of a peak intensity of the tetragonal crystalline structures with respect to a peak intensity of the monoclinic crystalline structures, and the peak intensity is defined as an integrated peak intensity.

2. The manufacturing method of a glass substrate for a magnetic disk recited in claim 1, wherein the zirconium oxide abrasive grains are made of aggregates of primary particles of zirconium oxide and the primary particles of zirconium oxide have both the monoclinic crystalline structures and the tetragonal crystalline structures.

3. The manufacturing method of a glass substrate for a magnetic disk recited in any of claims 1 to 2, wherein the zirconium oxide abrasive grains do not contain stabilizing agent.

4. The manufacturing method of a glass substrate for a magnetic disk recited in any of claims 1 to 3 wherein the average particle size D50 of the zirconium oxide abrasive grains is set to be in a range of 0.2 to 0.5 μm.

5. The manufacturing method of a glass substrate for a magnetic disk recited in any of claims 1 to 4, wherein a polisher pad is used for polishing a principal face of the glass substrate in the polishing step, the polisher pad having hardness in a range of 80 to 100 in JIS-A hardness.

6. A manufacturing method of a glass substrate for a magnetic disk, comprising:

a polishing step of executing polishing using a slurry containing yttrium-contained partially stabilized zirconia abrasive grains, each of the abrasive grains having yttrium-contained partially stabilized zirconia as a principal component, wherein a peak intensity of cubic crystalline structures is the highest among crystallites of crystalline structures of zirconia included in the yttrium-contained partially stabilized zirconia.

7. The manufacturing method of a glass substrate for a magnetic disk recited in claim 6, wherein the abrasive contains yttrium in a range of 1 to 6 % by mole.

8. The manufacturing method of a glass substrate for a magnetic disk recited in claim 7, wherein the abrasive contains yttrium oxide in a range of 1 to 6 % by mole.

9. The manufacturing method of a glass substrate for a magnetic disk recited in any of claims 1 to 8, wherein the glass substrate is made of glass, the glass having the fracture toughness value in a range of 0.4 to 1.5 $MPa \cdot m^{1/2}$.

10. The manufacturing method of a glass substrate for a magnetic disk recited in any of claims 1 to 9, further comprising:

a post polishing step of polishing using a slurry containing colloidal silica as abrasive grains , the post polishing step configured to be executed after the polishing step.

11. The manufacturing method of a glass substrate for a magnetic disk recited in claim 10, wherein a removal stock is set to be less than or equal to 5 μm in the post polishing step.

12. The manufacturing method of a glass substrate for a magnetic disk recited in claim 10 or claim 11, further comprising:

an intermediate polishing step of polishing using a slurry containing cerium oxide abrasive grains, the intermediate polishing step being executed between the polishing step and the post polishing step.

13. The manufacturing method of a glass substrate for a magnetic disk recited in any of claims 10 to claim 12, further comprising:

a chemically strengthening step configured to be executed between the polishing step and the post polishing step.

14. A magnetic disk made of a glass substrate manufactured with the method recited in any of claims 1 to 12, wherein at least a magnetic layer is formed on a principal face of the glass substrate.

15. A magnetic recording/reproducing device, comprising:

the magnetic disk recited in claim 14; and

a magnetic head embedded with a DFH (Dynamic Flying Height) control mechanism.