

DESCRIPTION

METHOD OF POLISHING THE INNER PERIPHERAL END SURFACES OF
SUBSTRATES FOR A RECORDING MEDIUM USING A BRUSH

5

CROSS REFERENCE TO RELATED APPLICATION

This application is an application filed under 35
U.S.C. §111(a) claiming benefit pursuant to 35 U.S.C.
§119(e) of the filing date of Provisional Application No.
10 60/606882, filed on September 3, 2004, pursuant to 35
U.S.C. §111(b).

Technical Field

The present invention relates to a method of
polishing the inner peripheral end surfaces of substrates
15 for a recording medium and a method of producing the
substrates by using the above method, etc.

Background Art

An aluminum substrate has been widely used as a
substrate for a magnetic recording medium such as a
20 magnetic disk. As the magnetic disks are being produced
in smaller sizes and smaller thickness but record data at
a higher density, an aluminum substrate is being
gradually replaced by a glass substrate having superior
surface flatness and substrate strength. As glass
25 substrates for magnetic recording medium, there have been
used chemically reinforced glass substrates for enhancing
the substrate strength and crystallized glass substrates
featuring increased substrate strength based on the
crystallization.

30 Accompanying the trend toward high-density
recording, further, the magnetic head is being changed
from a thin-film head to a magneto-resistive head (MR
head) and to a giant magneto-resistive head (GMR head).
It is therefore expected that reproducing the contents of
35 the magnetic recording medium of the glass substrate by
using magneto-resistive heads will become standard in the
future.

Thus, a variety of improvements have been made to the magnetic disk for high-density recording. Advances in the magnetic disk, however, are also accompanied by new problems concerning the glass substrate for the magnetic recording medium. One of them is to properly clean the surfaces of the glass substrate. That is, adhesion of a foreign matter on the surfaces of the glass substrate could become a cause of defects in the thin film formed on the surfaces of the glass substrate or a cause of protuberances formed on the surfaces of the thin film. Further, in reproducing the contents of the magnetic recording medium on the glass substrate by using a magneto-resistive head, if the flying height (floating height) of the head is lowered to increase the recording density, there may often occur erroneous reproducing operation or a phenomenon that the reproduction is not accomplished. The cause stems from the protuberances that are formed on the surface of the magnetic disk due to particles on the glass substrate turning into thermal asperity, generating heat in the magneto-resistive head, varying the resistance of the head, and adversely affecting the electromagnetic conversion.

A principal cause of foreign matter on the surface of the glass substrate for the magnetic recording medium described above is that the end surface of the glass substrate is not smooth and, hence, the end surface abrades the wall surface of a resin casing, whereby resin or glass particles formed by the abrasion, as well as other particles trapped on the inner peripheral end surface and the outer peripheral end surface of the glass substrate, adhere to the surfaces.

Patent document 1 (JP-A-11-221742) discloses a polishing method wherein a disk-like glass substrate (substrate for a recording medium) having a circular hole at the central portion is immersed in a polishing solution containing free grains, and the end surfaces of the glass substrate are polished by being brought into

rotational contact with a polishing brush or a polishing pad by using a polishing solution containing the free grains.

5 When the inner peripheral end surface of the substrate is to be polished by using the above slurry and the polishing brush, the polishing is effected by rotating the brush while dripping the slurry onto the center hole of the object to be polished which is formed by stacking a plurality of pieces of substrates aligned
10 with the center holes of other disk-like substrates having center holes, or inserting a rod-like polishing brush in the center hole in a state where the object to be polished is immersed in the slurry. According to this polishing method, however, the temperature rises due to
15 the friction with the object to be polished, the polishing material slurry and the polishing brush. The rise in temperature causes the rate of polishing to vary and makes it difficult to conduct the polishing while maintaining a correct amount of working. On the other
20 hand, a stack of substrates have been chamfered at the end surfaces and form dented portions at the chamfered portions among the upper and lower substrates. A difficulty is involved if it is attempted to polish the dented portions maintaining the same working precision as
25 for other end surfaces. It is desired to enhance the dimensional precision of the center holes of the disk-like substrates for a recording medium. Therefore, it is necessary to enhance the working precision in polishing the inner peripheral end surfaces.

30 [Patent document 1] Japanese Unexamined Patent Publication (Kokai) No. 11-221742

Disclosure of the Invention

It is, therefore, an object of the present invention to provide a method of polishing the inner peripheral end
35 surfaces of substrates while maintaining a sufficiently high working precision at the time of polishing the inner peripheral end surfaces of a plurality of disk-like

substrates for a recording medium.

The present invention provides a method of polishing the inner peripheral end surfaces of disk-like substrates for a recording medium and a method of producing the substrates by using the method described below.

(1) A method of polishing the inner peripheral end surfaces of disk-like substrates for a recording medium using a brush comprising:

providing a plurality of pieces of disk-like substrates for a recording medium having a circular hole at the central portion thereof thereby forming an inner peripheral end surface, and aligning and stacking the circular holes to form an object to be polished having the circular hole at the central portion thereof;

bringing a polishing material slurry containing a polishing material into contact with the object to be polished; and

inserting a polishing brush having brush hairs studded on the periphery of a rod-like shaft into the circular hole of the object to be polished in a state where the slurry is brought into contact with the object to be polished, and rotating the polishing brush with the shaft as a center to polish the inner peripheral end surfaces of the substrates;

wherein the polishing material slurry is controlled to remain at a constant temperature.

(2) The method of polishing using a brush according to (1) above, wherein the polishing brush is rotated and is reciprocally moved in a direction of inserting the brush relative to the object to be polished to effect the polishing.

(3) A method of producing disk-like substrates for a recording medium including a step of effecting the method of polishing using a brush according to (1) or (2) above.

(4) A substrate produced by the method of producing disk-like substrates for a recording medium according to (3) above.

(5) A method of producing a magnetic recording medium including a step of effecting the method of polishing using a brush according to (1) or (2) above.

According to the polishing method of the present invention which controls the temperature of the polishing material slurry to remain constant, it is made possible to maintain constant the rate of polishing the inner peripheral end surfaces of the substrates and, hence, to effect the polishing while maintaining a high dimensional precision.

Brief Description of the Drawings

Fig. 1 is a cross-sectional view of a polishing device that can be used in the polishing method of the present invention.

Fig. 2 is a cross-sectional view of the substrates that are stacked.

- 1 polishing device container
- 2 holding plate
- 3 substrate holder
- 4 rotary brush for polishing
- 5 rotary drive unit
- 6 polishing material slurry flow port
- 7 polishing material slurry
- 8 substrate
- 9 temperature sensor
- 10 chiller/temperature controller
- 11 slurry pipe
- 12 filter
- 13 cooling tank
- 14 pump
- 15 stirrer
- 16 cooling water pipe
- 100 polishing device

Best Mode for Carrying Out the Invention

The polishing method of the present invention is to simultaneously polish the inner peripheral end surfaces of a plurality of pieces of disk-like substrates, for a

recording medium and that are stacked, by using a slurry which contains a polishing material and a polishing brush having hairs studded on the periphery of the rod. Fig. 1 is a cross-sectional view schematically illustrating a polishing device that can be used in the polishing method of the present invention. A polishing device 100 includes a polishing device container 1, a holding plate 2, a substrate holder 3 installed on the holding plate 2, a rotary brush 4 for polishing, and a rotary drive unit 5. The interior of the polishing device container 1 is filled with a polishing material slurry 7. The brush 4 is brought into rotational contact with the inner peripheral end surfaces of the substrates 8 by using the polishing material slurry 7 that flows through a polishing material slurry flow port 6 and through the inside of the substrate holder 3. In this device 100, the substrates are immersed in the polishing material slurry 7, so that the substrates come in contact with the slurry 7.

In the method of the present invention, the temperature of the slurry 7 is maintained constant so as to maintain the rate of polishing constant. The temperature of the slurry 7 is measured by a temperature sensor 9 associated with a chiller unit/temperature controller 10, and the slurry is cooled in the cooling tank 13 so as to keep its temperature at a preset temperature. The slurry 7 from the polishing device 100 passes through a slurry pipe 11 and is, preferably, filtered through a filter 12 where substances produced by the polishing are removed and, then, enters into the cooling tank 13. The cooling tank 13 is of a double structure holding the slurry 7 in the inner side and circulating the cooling water in the outer side through a cooling water pipe 16. A stirrer 15 is provided in the cooling tank 13 to maintain the temperature of the slurry uniform and to prevent the polishing material from precipitating in the slurry. The temperature of the

cooling tank 13 is controlled by adjusting a temperature of a predetermined amount of cooling water, by adjusting a flow rate of cooling water to a predetermined temperature, or by adjusting both the amount and the temperature of the cooling water. The slurry 7 controlled to a predetermined temperature is returned back to the polishing device 100 through a pump 14. Thus, the temperature of the slurry 7 is maintained constant at the time of polishing. The temperature of the slurry 7 may be maintained constant to maintain the rate of polishing constant and may be at any temperature.

Next, Fig. 2 is a cross-sectional view of substrates that are stacked to form an object to be polished. An inner peripheral end surface 21 of each substrate is constituted by an end edge surface 22 and chamfered portions 23. A dented portion 24 is formed by the chamfered portions 23 at the end surfaces 21 between the upper and lower substrates. The dented portion 24 hardly comes into contact with the brush 4 and receives little contact pressure, to account for inferior polishing of the edge surfaces 22. Therefore, favorable and precise polishing can be effected if the brush 4 is moved up and down relative to the stack of substrates forming the object to be polished in addition to being rotated. The up-and-down motion can be realized by moving the brush 4 up and down or by moving the substrate holder 3 up and down.

In the present invention, the "up" and "down" directions are based on the upper and lower directions in Fig. 1.

There is no particular limitation on the polishing material or on the slurry that are used in the polishing method of the present invention, and there can be used any polishing material and any polishing material slurry that have been known in this field. Concretely, there can be used such polishing materials as rare earth oxide, iron oxide, zirconium oxide or silicon dioxide. To

polish the surfaces of the glass substrates, there can be used a polishing material containing rare earth oxide and, particularly, cerium oxide as a chief component on account of its polishing rate that is several times
5 superior to that of iron oxide, zirconium oxide or silicon dioxide. Described below is a polishing material slurry including cerium oxide though this is not intended to impose any limitation.

The polishing material slurry can be obtained by
10 dispersing in water the polishing material which contains, as a chief component, a rare earth oxide containing cerium oxide. The slurry may contain a dispersing agent, a chelating agent and the like as required.

15 As the polishing material comprising chiefly a mixture of rare earth oxides containing cerium oxide that is to be contained in the polishing material slurry, there can be exemplified a low-cerium polishing material of the bastnaesite type, containing cerium oxide in an
20 amount of about 50% by mass, or of the chlorinated rare earth type, a high-cerium polishing material of the synthetic type containing cerium oxide in an amount of 70 to 90% by mass, and a highly pure cerium oxide containing cerium oxide in an amount of not lower than 99% by mass.

25 The bastnaesite-type polishing material is obtained by pulverizing the bast naesite which is a fluorinated carbonate mineral of rare earth elements and by conducting the steps of chemical treatment, drying, roasting, milling, classifying and finishing. The
30 bastnaesite type polishing material contains about 50% by mass of cerium oxide and, further contains, other rare earth elements as basic fluorides, such as LaOF, NdOF, or PrOF. The chlorinated rare earth type polishing material is obtained by forming a hydroxide cake of a chlorinated
35 rare earth, drying it, roasting it as a partial sulfate, followed by milling, classifying and finishing, and contains cerium oxide in an amount of about 50% by mass

as well as other rare earth elements as basic anhydrous sulfates, such as $\text{La}_2\text{O}_3 \cdot \text{SO}_3$, $\text{Nd}_2\text{O}_3 \cdot \text{SO}_3$ and $\text{Pr}_5\text{O}_{11} \cdot \text{SO}_3$.

5 A high-cerium polishing material of the synthetic type is obtained by roasting a starting material such as bastnaesite, dissolving it by using nitric acid, heating it while adjusting the pH with a dilute ammonia water to hydrolyze Ce^{4+} to form a hydroxide thereof, and conducting the steps of filtering, drying, roasting, milling, classifying and finishing, and contains cerium oxide in
10 an amount of 70 to 90% by mass. The highly pure cerium oxide is obtained by dissolving an oxidized rare earth in a nitric acid, extracting Ce^{4+} existing in an aqueous solution with tributyl phosphate-benzene to transfer it into an organic phase, reversely extracting it with an
15 aqueous phase containing a reducing agent such as sodium nitrite to form cerium oxalate, followed by roasting. The purity of cerium oxide usually becomes as high as not less than 99.9% by mass.

The cerium oxide has a Moh's hardness of 5.5 to 6.5
20 which is equal to, or slightly higher than, the Mohs' hardness of a glass, and which can be finely adjusted. Therefore, the cerium oxide can be favorably used as a material for polishing glass. Both the low-cerium polishing material and the high-cerium polishing material
25 have excellent polishing power. Here, however, the high-cerium polishing member has the feature of a particularly long life. Though there is no particular limitation on the particle size of the polishing material comprising chiefly a mixture of rare earth oxides including cerium
30 oxide used for the polishing material composition, there can be preferably used a polishing material having particle sizes corresponding to a cumulative value of 50% of volume distribution of 0.5 to 3 μm as measured in compliance with JIS R 6002, "6. Method of Testing
35 Electric Resistance". It is desired that the crystal system of the cerium oxide is a cubic system.

The polishing material slurry may contain a

chelating agent, as required. When the chelating agent is contained, the reactivity of the glass component formed by polishing can be lowered. In conventional polishing of the glass surfaces for finishing, the polishing material slurry is usually used by being circulated. As the polishing material slurry is used for extended periods of time, however, the glass component which is the object to be polished gradually increases in the slurry that is used by being circulated. If the glass component uniformly covers the surfaces of the polishing material particles, not only the precipitate of the polishing material becomes very hard but also the precipitate of the polishing material deposits thereon again due to its high affinity to the glass surfaces, deteriorating the ability of the glass to be washed.

If the polishing material slurry contains a chelating agent, the reactivity drops between the surfaces of the polishing material particles and the surfaces of the glass, and the surfaces of the polishing material particles are prevented from being covered with the glass component. As a result, no hard precipitate forms and the deterioration of an ability to be washed is inhibited. Preferred concrete examples of the chelating agent include o-phenanthroline, gluconic acid and a salt thereof, amino acid and ethylenediaminetetraacetic acid. As the gluconic acid and the salt thereof, there can be exemplified a gluconic acid and a sodium salt, a calcium salt, a zinc salt and a ferrous salt thereof.

There is no particular limitation on the amino acid that is contained, and there can be used, for example, an acidic amino acid, a neutral amino acid, a basic amino acid, metal salts thereof, and compounds in which hydrogen atoms of the amino group of the amino acid are partly substituted with an alkyl group, a hydroxylalkyl group or an alkoxyl group. However, if the polishing material slurry becomes acidic, the chemical effect of the cerium oxide itself, for polishing the glass, drops

and the working speed decreases. When the acidic amino acid is to be used, therefore, it is desired to also use a basic amino acid in combination. Further, the amino acid may be either the one that naturally exists or one that is synthesized. Moreover, the amino acid having an optical isomer may be either of the D-type or the L-type.

As the amino acid that can be used for the polishing material slurry, there can be exemplified glycine, alanine, valine, leucine, isoleucine, cerin, threonine, cysteine, cystine, methionine, aspartic acid, glutamic acid, lysine, alginine, phenylalanine, tyrosine, histidine, tryptophane, proline, hydroxyproline, diiodotyrosine, thyroxine, hydroxylysine, β -alanine, γ -aminobutyric acid, anthranilic acid, m-aminobenzoic acid, and p-aminobenzoic acid. Among them, glycine and alginine can be particularly preferably used. The amino acid can be used in one kind alone or in two or more kinds in combination.

Among the above chelating agents, it is desired to use o-phenanthroline and gluconic acid as well as a salt thereof. It is desired that the content of the chelating agent is 0.05 to 0.3% by mass. When its content is smaller than 0.05% by mass, the effect of suppressing the reactivity of the glass component is poor. When its content exceeds 0.3% by mass on the other hand, the polishing rate decreases.

The polishing material slurry can further contain an acetonato complex of aluminum having 1 to 3 acetonato ligands. When the acetonato complex of aluminum is contained, the polishing material is suppressed from adhering to the glass substrate or to the polishing device, and lowering of the ability to be washed is prevented. Usually, the polishing material is a super fine powder having an average particle size of about 1 to about 2 μm . Due to its surface activity, the polishing material exists while being aggregated in the polishing slurry. The aggregated particles lower the apparent

surface area and suppress the polishing material from adhering onto the glass substrate and the polishing device. However, the particles on the outermost shell maintain their activity. Once adhered to the glass
5 substrate and the polishing device, the particles can no longer be removed by washing such as by running water or an ultrasonic application. The ordinary polishing material tends to adhere onto the glass substrate and the polishing device. Contrary to this, the polishing
10 material containing the acetonato complex of aluminum does not adhere due to the interaction between the acetonato complex of aluminum and the aggregated particles of the polishing material in the polishing material slurry, preventing lowering in the ability to be
15 washed.

Concrete examples of the acetonato complex of aluminum that is used include a complex having an acetyl acetate (R = methyl) ligand such as aluminum
20 tris(acetylacetate) and a complex having an ethyl acetoacetate (R = ethoxy) ligand such as aluminum tris(ethyl acetoacetate). Among them, it is desired to use aluminum tris(acetylacetate). The acetonato complex of aluminum may be the one having two or three kinds of different acetonato ligands in a molecule.
25 Further, the acetonato complex of aluminum may be used in a single kind or in two or more kinds in combination. It is desired that the content of the acetonato complex of aluminum is 0.05 to 0.3% by mass. When the content is smaller than 0.05% by mass, the effect of preventing the
30 adhesion to the polishing material is poor. When the content exceeds 0.3% by mass, on the other hand, the polishing rate decreases.

To improve the dispersion of particles, to prevent sedimentation and to improve workability, the polishing
35 material slurry may be further blended, as required, with glycols such as ethylene glycol and polyethylene glycol, phosphates such as tripolyphosphate and

hexametaphosphate, polymeric disperants such as polyacrylate, cellulose ethers such as methyl cellulose and carboxymethyl cellulose, and water-soluble polymers such as polyvinyl alcohol. The amount of their addition to the polishing material is, usually, 0.05 to 20% by mass, preferably, 0.1 to 15% by mass and, more preferably, 0.1 to 10% by mass.

The polishing material slurry is usually used while being dispersed in a dispersant such as water at a concentration of about 5 to 30% by mass. As the dispersant, there is used water or a water-soluble organic solvent. As the water-soluble organic solvent, there can be exemplified alcohol, polyhydric alcohol, acetone and tetrahydrofuran. Water, however, is usually used. It is also allowable to add an assistant that is usually used for an ordinary cerium oxide polishing material.

The slurry used in the method of the present invention may be obtained by mixing starting materials together and has no particular limitation. Desirably, however, the slurry may be mechanically mixed and prepared at the above mixing ratio by using a ball mill or a high-speed mixer.

The end surfaces of the substrates are usually polished after a circular hole at the centers of the glass substrates is formed and the inner peripheral end surfaces and the outer peripheral end surfaces are chamfered. Thereafter, the substrates may be polished on the recording surfaces thereof and, as required, are, further, chemically strengthened by using a chemical strengthening solution such as potassium nitrate or sodium nitrate.

On the thus fabricated substrates, there are successively overlaid an underlying layer, a magnetic layer, a protection layer and a lubricating layer to produce a magnetic recording medium. As the underlying layer, there can be usually used a nonmagnetic material

such as Cr, Mo, Ta, W, V, B or Al though this is not to impose any limitation. As the magnetic layer, there can be used a magnetic film comprising chiefly Co. As the protection layer, there can be used a Cr film or a carbon film. The lubricating layer is formed by diluting a perfluoroether which is a liquid lubricant with a fluoro-type solvent, applying it and drying it.

Examples

The method of the present invention will be described in further detail by way of an Example which, however, is not intended to limit the invention.

Example 1.

150 pieces of glass substrates (TS-10SX manufactured by Ohara Co.) for a hard disk (HD) each having a diameter (outer diameter) of 65 mm, a diameter (inner diameter of the center hole) of 20 mm and a thickness of 0.635 mm, were stacked and were subjected to the polishing on their inner peripheral end surfaces by using a polishing device shown in Fig. 1 under the conditions described below.

The inner peripheral end surface of the substrate included an end edge surface of 0.335 mm and chamfered portions of 0.150 mm on both sides thereof.

1. Polishing:

1.1. Polishing material slurry.

Kind of polishing material, grain size: cerium oxide (SHOROX A-10 manufactured by Showa Denko Co.), average particle size, 1.4 μm .

Dispersion medium: water

Dispersing agent: sodium hexametaphosphate

Concentration of polishing material in the slurry: 10% by mass

Material of brush, length of hair, diameter of hair: nylon, 4 mm, ϕ 0.15 mm.

Rotational speed of brush: 2400 rpm

Polishing time: 20 min.

The temperature of the polishing slurry was

controlled to be 25°C by using a mechanism shown in Fig.
1.

Comparative Example 1.

5 The polishing was conducted in the same manner as in
Example 1 above but without controlling the temperature.
The temperature was 26°C at the start of the polishing but
was elevated to 30°C at the end of the polishing.

2. Testing for evaluation.

2.1. Observing defects on the surface.

10 The substrates polished in Example and in
Comparative Example above were observed for defects on
the surfaces. The surfaces were observed along the whole
inner peripheral end surfaces by using a microscope
manufactured by Olympus Co. at a magnification of 200
15 times.

2.2. Inspecting the sizes of the inner peripheral end surfaces.

A total of three substrates were measured for their
sizes including two substrates of the outermost sides and
20 one substrate at the center that were polished in Example
and in Comparative Example above. The results were as
shown in Table 1 below. The results are average values
of the sizes of the three substrates.

25

Table 1

	Example 1	Comparative Example 1
Polishing temp. (°C)	25°C (constant)	26 to 30°C
Inner diameter before polished (mm)	19.995	19.995
Inner diameter after polished (mm)	20.011	20.014
Amount polished (μm)	16	19

30

From the above results of testing, it was confirmed
that the surfaces were observed to contain no scars or no
pits in both Example 1 and Comparative Example 1. As for
the sizes of the inner peripheral end surfaces, the

polishing amount was 16 μm as expected in Example 1
whereas the polishing amount was 19 μm in Comparative
Example 1, which was larger by 3 μm than the expected
amount. By controlling the temperature to remain
5 constant at the time of polishing, the rate of polishing
(rate of working) becomes stable, and there is obtained
the inner diameter which is nearly the same as the target
value. This further suppresses dispersion in the inner
diameter caused by a change in the hardness of the brush
10 stemming from local elevation of the temperature.

CLAIMS

1. A method of polishing the inner peripheral end surfaces of disk-like substrates for a recording medium using a brush comprising:

5 providing a plurality of pieces of disk-like substrates for a recording medium having a circular hole at the central portion thereof thereby forming an inner peripheral end surface, and stacking them while aligning the circular holes to form an object to be
10 polished having the circular hole at the central portion thereof;

bringing a polishing material slurry containing a polishing material into contact with said object to be polished;

15 inserting a polishing brush having brush hairs stud on the periphery of a rod-like shaft into the circular hole of said object to be polished in a state where said slurry is brought into contact with said object to be polished, and rotating the polishing brush
20 with the shaft as a center axis to polish the inner peripheral end surfaces of the substrates;

wherein said polishing material slurry is controlled to remain at a constant temperature.

2. The method of polishing using a brush according to claim 1, wherein the polishing brush is rotated and is
25 reciprocally moved in a direction of inserting the brush relative to the object to be polished to effect the polishing.

3. A method of producing disk-like substrates for a recording medium including a step of effecting the
30 method of polishing using a brush according to claim 1 or 2.

4. A substrate produced by the method of producing disk-like substrates for a recording medium of claim 3.

35 5. A method of producing a magnetic recording medium including a step of effecting the method of polishing using a brush of claim 1 or 2.