

MAGNETIC RECORDING MEDIUM AND THE METHOD OF MANUFACTURING THE SAME

Field of the Invention

5 The present invention relates to magnetic recording media mounted on data storages for computers and such information processing apparatuses or on data storages (especially hard disk drives) for household appliances. The present invention relates also to the method of manufacturing the magnetic recording media.

10 Prior Art

 Recently, the storage capacities of the data storages and the recording capacities of the magnetic recording media (hereinafter referred to simply as the “magnetic disks”) used for the information processing apparatuses including computers have been increased steadily in association with the increase of the data processed by the
15 information processing apparatuses and the downsizing of the information processing apparatuses. In association with the storage capacity increase, the rotating speed of the magnetic disk has been increased more and more to improve the data transfer speed. In these days, some hard disk drives rotate the magnetic disks at 15,000 rpm.

 The natural vibration of the magnetic disk caused by the rotation thereof is
20 hazardous for high-speed rotation of the magnetic disk. The vibration of the magnetic disk caused by the rotation thereof prevents the magnetic head from fly-ability, impairing the reliability of the hard disk drive badly. To obviate this problem, glass disks exhibiting high rigidity have been used recently for facilitating high-speed rotation. However, the glass disks are expensive at present, and the expensive glass
25 disks increase the total costs of the hard disk drives. Therefore, it has been necessary to realize stable high-speed rotation by employing relatively cheap aluminum disks.

 The aluminum disks have been thickened from 0.8 mm to 1.0 mm and further to 1.27 mm to improve the rigidity thereof and to confine the natural vibration thereof within a tolerable range. Recently, an aluminum disk of 1.6 mm in thickness has been
30 proposed.

 Usually, the magnetic disk includes an aluminum substrate, a nonmagnetic metal

undercoating layer on the aluminum substrate, a magnetic layer on the undercoating layer, and a protection layer on the magnetic layer. The undercoating layer, the magnetic layer, and the protection layer are formed by sputtering, chemical vapor deposition (CVD) and such a conventional method for film deposition. A lubricant is coated on the laminate formed so far. The lubricant is coated in many cases by dip-coating due to the excellent mass-productivity thereof and the simplicity of the equipment for the dip-coating. The dip-coating is conducted in the following way. The stock solution of a liquid lubricant is diluted to an appropriate concentration considering the desired film thickness with a solvent (such as an organic fluorocarbon solvent). The disk with the laminate formed thereon is dipped for a certain period of time in the liquid lubricant solution prepared as described above. Then, the disk is pulled out of the liquid lubricant solution at a constant speed to evaporate the solvent and to absorb the lubricant component remaining on the disk onto the protection layer. Thus, a thin lubricant layer is formed on the protection layer. Alternatively, spin-coating and spray-coating are employable for forming the lubricant layer.

Problems to be solved by the Invention

Although the dip-coating method has been employed for forming the lubricant layer, it has been found that a lot of lubricant localizes to (remains on) the end face portion of the magnetic disk opposite to the direction, to which the magnetic disk is pulled up, and the remaining lubricant migrates with elapse of time to the peripheral portions in the major surfaces of the magnetic disk. Referring now to FIG. 6, the arrow A indicates the direction, to which the magnetic disk has been pulled up, and the darkened regions are the regions, to which the lubricant has migrated.

As the magnetic disk is thicker, the absolute amount of the lubricant migrating to the peripheral portions of the major surfaces becomes larger, since more amount of the lubricant localizes to the end face of the magnetic disk in proportion to the area thereof. The lubricant is liable to migrate to the slider of the magnetic head flying over the peripheral portions of the magnetic disk, to which the lubricant has migrated. As a result, the flying of the magnetic head becomes unstable, and the unstable flying of the magnetic head affects adversely the magnetic parametric performances and the durability against head seek (the durability against swinging). Although the typical

flying height of the magnetic heads is around 10 nm, the flying height of the magnetic heads will be lower in the perpendicular magnetic recording system expected to be used in practice in future than the flying height in the conventional parallel magnetic recording system. The lubricant migration will pose serious problems on the magnetic heads flying at a lower height.

The problem of lubricant migration has been intangible so far, since the lubricant amount on the end face of the magnetic disk was not included in the control items, since the magnetic disks were as thin as 0.8 mm or less, and since the flying height of the magnetic heads was from 15 to 20 nm, relatively higher than the present flying height of the magnetic heads.

Although the lubricant concentration is optimized, the solvent for diluting the lubricant is selected, and the pulling-up speed is optimized to prevent the lubricant migration from causing, it is impossible at present to completely prevent the lubricant migration from causing.

Japanese Unexamined Laid Open Patent Application 2003-6849 and Japanese Examined Patent Application H07 (1995)-58545 disclose the proposals, which press a wiper or a buff onto the disk surface, on which the lubricant is coated, to uniformly distribute the lubricant and to flatten the disk surface. However, the wiping treatment and the buffing treatment are applied only to the major surface of the magnetic disk, that is to the head flying region and the recording region, solely to improve the frictional performances such as the constant start stop (CSS) performance and to prevent the magnetic head from sticking to the magnetic disk. The wiping treatment and the buffing treatment have failed to obviate the problems of lubricant migration, in which the lubricant deposited on the end face of the magnetic disk migrates onto the major surfaces of the magnetic disk with elapse of time.

In view of the foregoing, it would be desirable to obviate the foregoing problems of lubricant migration. It would be also desirable to provide a manufacturing method, which wipes off the lubricant deposited on the end face of the magnetic disk with a wiper containing a solvent to prevent the lubricant deposited on the end face of the magnetic disk from migrating onto the major surfaces of the magnetic disk or solidifies the lubricant deposited on the end face of the magnetic disk by ultraviolet

ray irradiation to deprive the lubricant of the fluidity. It would be also desirable to manufacture magnetic recording media by the methods described above.

5 Means for solving the Problems

According to a first aspect of the invention, there is provided a method of manufacturing a magnetic recording medium including a magnetic layer, a protection layer on the magnetic layer, and a liquid lubricant layer on the protection layer, the method including the steps of: coating the liquid lubricant layer on the protection layer, and pressing at a constant pressure a wiping tape containing a solvent to the end face of the rotating magnetic recording medium to wipe off the portion of the liquid lubricant layer coated on the end face of the magnetic recording medium.

According to a second aspect of the invention, there is provided a method of manufacturing a magnetic recording medium including a magnetic layer, a protection layer on the magnetic layer, and a liquid lubricant layer on the protection layer, the method including the steps of coating the liquid lubricant layer on the protection layer, and irradiating an ultraviolet ray to the end face of the rotating magnetic recording medium to solidify the lubricant component in the liquid lubricant layer coated on the end face of the magnetic recording medium.

Advantageously, the end face includes a side face portion including chamfer sections of the magnetic recording medium shaped with a circular disk having a certain thickness but excluding at least the magnetic head flying region of the magnetic recording medium.

Advantageously, a magnetic recording medium may be manufactured by any of the methods described above.

The wet-wiping removes the lubricant and the ultraviolet ray irradiation solidifies the lubricant. These treatments are applied only to the end face of the magnetic disk according to the invention, since these treatments impair the lubricity of the faces, to which any of these treatments is applied. In unfavorable environments in the hard disk drive containing gases generated or dusts, the magnetic head flying at the flying height of around 10 nm employed in these days may come into contact intermittently

with the head flying region of the magnetic disk, and head crash will be caused in the worst case. For preventing the head contact or the head crash from causing, it is necessary to leave the lubricant component on the head flying region without being removed or without being solidified.

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Brief Description of the Drawing Figures

FIG. 1 is a block diagram schematically showing the manufacturing setups for applying a wet-wiping treatment and for applying an ultraviolet ray irradiation treatment to the end face of a magnetic disk.

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FIG. 2 is a cross sectional view of a magnetic recording medium (magnetic disk) treated with the setups of FIG. 1.

FIG. 3 is a cross sectional view schematically showing the maximum region of the end face of a magnetic disk, to which the treatments according to the invention are applied.

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FIGs. 4(A) through 4(D) are schematic OSA images showing the states on the surfaces of magnetic disks obtained by the OSA.

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FIG. 5 shows the results of film thickness measurement conducted using a Fourier transform infrared spectrophotometer (FTIR) indicating that the portions in the major surfaces of the magnetic disks, thereto the lubricant has migrated, are thicker by around 5Å than in the other portions.

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FIG. 6 is a top plan view of a magnetic disk including the major surface portions thereof, onto which the lubricant has migrated.

Modes for carrying out the Invention

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Now the invention will be described in detail hereinafter with reference to the accompanied drawing figures which illustrate the preferred embodiment of the invention.

Methods and Setups for Manufacture

FIG. 1 is a block diagram schematically showing the manufacturing setups for applying a wet-wiping treatment and for applying an ultraviolet ray irradiation treatment to the end face of a magnetic disk.

In FIG. 1, the rotation direction of a magnetic disk 11, onto which a lubricant has been coated, is indicated by the arrow R. In FIG. 1, an end-face wet-wiping unit 12 including a wiping tape 13 and a pad 14, a solvent spray nozzle 15, and a solvent storage tank 16 for feeding a solvent to spray nozzle 15 are shown. An ultraviolet ray irradiation unit (hereinafter referred to as a "UV irradiation unit") 17 including a UV lamp 18, a shield 19, and a slit (a long and fine hole) 20, is also shown in FIG. 1. Although wet-wiping unit 12 and ultraviolet ray irradiation unit 17 are shown in FIG. 1, any of wet-wiping unit 12 and UV irradiation unit 17 may be installed solely with no problem.

The treatment using wet-wiping unit 12 is conducted in the following way. Magnetic disk 11 with a lubricant layer formed thereon is rotated to a certain direction R. A solvent is ejected onto wiping tape 13 on the feeding side thereof from spray nozzle 15. Wiping tape 13 is fed at the start of every treatment and the feed thereof is stopped during the treatment. The wet section of wiping tape 13 containing the solvent sprayed thereto is pressed to the end face of magnetic disk 11 with pressing pad 14 at a predetermined pressure to wipe off the lubricant layer coated on the end face of magnetic disk 11 with wiping tape 13. The arrows illustrated near wiping tape 13 in FIG. 1 indicate the direction, to which wiping tape 13 is fed or wound up.

The treatment using UV irradiation unit 17 is conducted in the following way. Magnetic disk 11 with a lubricant layer formed thereon is rotated to a certain direction R. The lubricant component in the lubricant layer coated on the end face of magnetic disk 11 is solidified by irradiating an ultraviolet ray from UV lamp 18 to the end face of magnetic disk 11 through slit 20 opened in shield 19. For example, slit 20 is 2 mm in width and 5 mm in length.

Structure of Magnetic Recording Medium

FIG. 2 is a cross sectional view of a magnetic recording medium (magnetic disk) treated with the setups of FIG. 1.

Referring now to FIG. 2, the magnetic disk includes an aluminum substrate 21 (1.27 mm in thickness), a nonmagnetic metal undercoating layer 22 on substrate 21, a magnetic layer 23 on undercoating layer 22, a protection layer 24 on magnetic layer 23, and a liquid lubricant layer 25 on protection layer 24. Undercoating layer 22, magnetic layer 23, and protection layer 24 are formed one by one by the sputtering method or by the CVD method. Liquid lubricant layer 25 is formed, for example, by the conventional dipping method described earlier in connection with the prior art. A plastic substrate and such a nonmagnetic substrate may be used in substitution for aluminum substrate 21 with no problem.

Machining Region

FIG. 3 is a cross sectional view schematically showing the maximum region of the end face of a magnetic disk, to which the treatments according to the invention are applied.

In FIG. 3, the maximum region of an end face 34, to which the treatments according to the invention are applied, and magnetic head flying regions 33 are shown. End face 34 includes a side face section 31 and chamfer sections 32. In the descriptions of the invention, the term "end face" designates the entire side face portion, including chamfer sections 32, of a circular magnetic recording medium (magnetic disk) 11 having a certain thickness. Magnetic head flying regions 33 are excluded from the "end face".

Experiments

Four kinds of magnetic disks (A) through (D) having the structure shown in FIG. 2 are fabricated.

Magnetic disk (A): any of the above described treatments is not applied thereto

after the lubricant coating.

Magnetic disk (B): the end face thereof is wiped with a dry wiper in wiping unit 12, from which spray nozzle 15 is removed.

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Magnetic disk (C): the end face thereof is wiped with a wet wiper, containing a solvent, of wet-wiping unit 12.

10 Magnetic disk (D): the end face thereof is irradiated with an ultraviolet ray using UV irradiation unit 17.

15 The magnetic disks fabricated are left in an environment, kept at the normal temperature and the normal humidity, for a week. Then, the major surfaces of the magnetic disks are observed under an optical surface analyzer (hereinafter referred to as an "OSA").

20 In fabricating the magnetic disks (B) and (C), a wiper (called also a "wiper tape" or a "wiping tape", TORAYSEE 53203TR supplied from TORAY INDUSTRIES, INC.) is used. In fabricating the magnetic disk (C), a solvent (Vertrel XF supplied from Du Pont Co.) is used for wet-wiping. Although any solvent may be used as far as the solvent dissolves the lubricant used, it is preferable to use the solvent used for coating the lubricant in manufacturing the magnetic disk. Preferably, the wiper is resistive against the solvent used in wiping off the lubricant.

25 The setup for end face wiping as shown in FIG. 1 is set up by the present inventor for use in the Fuji Electric Co., Ltd. The solvent is ejected onto wiping tape 13 on the feeding side thereof from spray nozzle 15. Wiping tape 13 is fed at the start of every wiping treatment and the feed of wiping tape 13 is stopped during the wiping treatment. Wet tape 13 is pressed to the end face of magnetic disk 11 by pad 14, the hardness thereof is 60 degrees (60°). If the hardness of pad 14 is too low, the circumference of disk 11 is pressed into pad 14 and the magnetic head flying regions 33 (cf. FIG. 3) on the major surfaces of disk 11 may be wiped. Therefore, it is not desirable for pad 14 to be too soft. During the wiping treatment, disk 11 is rotated at 30 200 rpm. The pressure, under which tape 13 is pressed to the end face of disk 11, is 0.5

kg/cm². Each wiping treatment is conducted for 10 sec.

UV lamp 18 used in fabricating magnetic disk (D) emits an ultraviolet ray having wavelengths of 185 nm and 254 nm. UV lamp 18 is spaced apart for the shortest distance of 10 mm from the end face of magnetic disk 11. The ultraviolet ray is irradiated at the strength of from 10 mW/cm² to 15 mW/cm² for 10 sec. in each irradiation treatment. UV lamp 18 is covered with shield 19, a slit 20, 2mm in width and 5 mm in length, is opened in a part of shield 19, and slit 20 is positioned in closest proximity to the end face of magnetic disk 11 so that the ultraviolet ray may be irradiated only to the end face of magnetic disk 11.

Experimental Results

The magnetic disks (A) through (D) fabricated are left in an environment, kept at the normal temperature and the normal humidity, for a week. Then, the major surfaces of the magnetic disks (A) through (D) are observed under an OSA (OSA 5100 supplied from Candela Instrumens). The OSA is an instrument that quantitatively determines the state of a material (such as carbon, a lubricant, and a contaminant) on a reflective layer (such as a magnetic layer and a carbon layer) by irradiating a laser beam consisting of a P polarized wave (longitudinal wave) or an S polarized wave (transversal wave) obliquely onto the surface of the layer to be analyzed and by detecting the phase difference of the reflective beam. In the present experiment, the phase difference change of a Q polarized wave consisting of a P polarized wave and an S polarized wave is employed, since the use of the Q polarized wave facilitates more sensitive analysis than the use of the P polarized wave or the S polarized wave. The phase difference change of the Q polarized wave is the difference of the phase difference between the P polarized wave and the S polarized wave in the incident beam and the phase difference between the P polarized wave and the S polarized wave in the reflective beam.

FIGs. 4(A) through 4(D) are schematic OSA images showing the states on the surfaces of magnetic disks obtained by the OSA described above. FIGs. 4(A) through 4(D) show the respective surface states of the corresponding magnetic disks (A) through (D). The original pictures of FIGs. 4(A) through 4(D) are color photographs. If the color photographs are converted to black and white pictures with

half tones, the images will not exhibit clear contrasts. To avoid this problem, the contrasts are intensified so that the portions illustrated by black (dark) may be clearly perceivable.

As FIGs. 4(C) and 4(D) indicate, lubricant migration onto the major disk surfaces is prevented from causing in the magnetic disk (C) treated by wet-wiping and the magnetic disk (D) treated by UV irradiation. As FIG. 4(B) indicates, the dry-wiping treatment is not effective.

The effects of the treatments are judged by the OSA determination. In the image processing, the contrast range of the lubricant layer thickness is adjusted at around 5Å. If any portion illustrated by black (dark) is not found, it is determined that the treatment is effective. The portion illustrated by black (dark) is a portion, in which the lubricant layer is thicker (that is a portion, into which the lubricant has migrated from the end face of the magnetic disk).

The lubricant layer thickness in the black (dark) portions is measured with a Fourier transform infrared spectrophotometer (FTIR). Results are shown in FIG. 5. In FIG. 5, the horizontal axis represents the position in the disk major surface measured from the reference position and expressed by degrees of angle and the vertical axis represents the lubricant layer thickness. The portions (such as the portions around the 15 degrees of angle and 180 degrees of angle on the sample 1), therein the lubricant layer is thicker than in the surrounding portions, are the portions illustrated by black (dark) on the OSA image. Thus, it has been confirmed also by the FTIR layer thickness measurement that the portions illustrated by black (dark) on the OSA image are thicker by around 5Å than the other portions. Since the measurement with the FTIR takes a long time, the lubricant migration is detected usually from the OSA images.

Changes and Modifications

Although the invention has been described in connection with the preferred embodiments and the experiments thereof, changes and modifications such as change of the relevant numerical values, employment of similar methods and materials, and combinations with the conventional techniques are obvious to those skilled in the art

without departing from the true spirits of the invention. For example, combination of the wet-wiping treatment and the UV irradiation treatment may be an additional embodiment according to the invention. Therefore, the invention be understood not by the specific descriptions herein but by the appended Claims thereof.

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Advantageous Effects of the Invention

As described above, the lubricant deposited on the end face of the magnetic disk is wiped off with a wet wiping tape or solidified by irradiating an ultraviolet ray to the end face of the magnetic disk. Therefore, the lubricant deposited on the end face of the magnetic disk is prevented from migrating onto the major surfaces of the magnetic disk and the reliability thereof is improved.

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Claim

What is claimed is:

1. A method of manufacturing a magnetic recording medium including a magnetic layer, a protection layer on the magnetic layer, and a liquid lubricant layer on the protection layer, the method comprising the steps of:

coating the liquid lubricant layer on the protection layer, and

irradiating the end face of the rotating magnetic recording medium with ultraviolet ray, whereby to solidify the lubricant component in the liquid lubricant layer coated on the end face of the magnetic recording medium,

wherein the magnetic recording medium is disk shaped.

2. The method according to Claim 1, wherein the end face comprises a side face portion including chamfer sections of the magnetic recording medium shaped with a circular disk having a certain thickness but excluding at least the magnetic head flying region of the magnetic recording medium.

3. The magnetic recording medium manufactured by the method described in any of the Claims 1 through 2.