

DESCRIPTION

METHOD OF MANUFACTURING A GLASS SUBSTRATE FOR A MAGNETIC DISK

Technical Field

This invention relates to a method of manufacturing a glass substrate for a magnetic disk.

Background Art

In recent years, the information recording technique, particularly the magnetic recording technique, has remarkably advanced following the development of information technology. With the reduction in size and thickness and the increase in recording density of magnetic disks, glass substrates excellent in substrate surface flatness and substrate strength have started to be used as substrates for magnetic recording media such as HDDs (hard disk drives) being one of the magnetic recording media, instead of aluminum substrates that have conventionally been widely used.

A magnetoresistive head (MR head) or giant magnetoresistive head (GMR head) controls the flying height by the pressure of air between the relatively moving magnetic head and magnetic disk. That is, the flying height of the magnetic head from the magnetic disk is determined by a balance between a positive pressure (a pressure exerted in a direction in which the magnetic head flies from the magnetic disk) and a negative pressure (a pressure in a direction in which the magnetic head is adsorbed to the magnetic disk, generated by increasing the volume of air and thus reducing the pressure in a space intentionally provided at the bottom surface of a slider of the magnetic head) generated by an air flow.

As one of techniques for stabilizing the control of the magnetic head flying height described above and achieving a further reduction in flying height, the technique called DFH (Dynamic Flying Height) has been developed in recent years. A heater element is embedded in a magnetic head and, during operation of the magnetic head, the heater element is heated. The magnetic head is thermally expanded by its heat and slightly projected toward a magnetic disk. By this, the magnetic spacing being a magnetic gap between the magnetic head and the main surface of the magnetic disk can be reduced only in that event. That is, DFH is a technique that can reduce the flying height of a magnetic head from a magnetic disk.

With such a DFH head, a further reduction in flying height has been achieved. However, a magnetic head is mounted with an MR element and there is a problem that it causes, as its inherent failure, the head crash failure or thermal asperity failure. Since these failures occur due to minute irregularities on the surface of a magnetic disk, the main surface of the magnetic disk is required to have extremely high-level smoothness and flatness. As means for evaluating the flying characteristics affected by the smoothness of a magnetic disk, an inspection is carried out, for example, by a glide test (a method of disposing a glide head (a head equipped with an impact detecting sensor such as a PZT (piezoelectric element)) so as to face the main surface of a magnetic disk and evaluating the flying characteristics by relatively moving the glide head with respect to the magnetic disk at a predetermined glide height).

Therefore, even glass substrates excellent in flatness as compared with aluminum substrates have been required to have further smoothness and flatness. Herein, similar to or more than smoothly and flatly polishing the glass substrates, particles such as dust that adhere to the main surfaces of the glass substrates become a problem. This is because if a magnetic layer is formed on a glass substrate contaminated with particles, convex defects occur on a

magnetic disk to cause the head crash failure or thermal asperity failure.

Therefore, the operation of forming magnetic layers/protective layers etc. on the main surfaces of the glass substrates is normally carried out in a clean room.

Herein, there arises a problem of particles that adhere to the glass substrates while transporting the glass substrates to a magnetic disk production site from the manufacture of the glass substrates. Generally, in a magnetic disk production process, the glass substrates are first cleaned to thereby remove adhering particles. However, it is not possible to remove any amounts of particles. If there is a difference in amount of particles adhering to the glass substrates, there also occurs a difference in amount of particles remaining on the glass substrates after the cleaning. Therefore, it is necessary to reduce as much as possible the particles adhering to the glass substrates at the time of transfer-in (after unpackaging) and, for this, a packaging method, an unpackaging method, a packaging structure, and a packaging material included in a glass substrate or magnetic disk manufacturing method are extremely important.

Herein, as a method of removing dust having a polarity and floating in a room where glass substrates or the like are packaged, for example, JP-A-H7-284661 discloses coating charged paint on wall and floor surfaces to cause the dust in the room to be adsorbed onto the wall and floor surfaces, thereby maintaining the cleanness in the room.

Further, for example, JP-A-2002-50499 discloses a method of blowing an air ion flow onto charged glass substrates to neutralize the charge, thereby preventing electrostatic adsorption of dust onto the glass substrates.

Disclosure of the Invention

Although the packaging technique for preventing contamination of magnetic-disk glass substrates is proposed in JP-A-H7-284661, even if such a

packaging technique is applied to packaging of glass substrates, a reduction in adhesion amount of dust on the glass substrates after unpackaging has not become satisfactory. Therefore, it has not been possible to satisfy the standard of smoothness/flatness required for magnetic disks following the increase in recording density of magnetic disks and the reduction in flying height of magnetic heads in recent years. Thus, it is necessary to further reduce adhesion of dust to glass substrates.

Further, if the polarity of the magnetic-disk glass substrates is opposite to that of the dust, it is possible that magnetic disks adsorb the dust and thus there is a possibility of contamination of the surfaces of the magnetic disks.

As described in JP-A-2002-50499, the charge can be removed by blowing an air ion flow onto magnetic-disk glass substrates. However, even if the magnetic-disk glass substrates are electrically neutralized, it is only possible to prevent electrostatic adsorption, but it is not possible to prevent dust floating in air from adhering to the glass substrates. Therefore, preparation toward an increase in recording density is not sufficient and it is necessary to further reduce adhesion of dust to magnetic-disk glass substrates.

In view of the problems described above, it is an exemplary object of this invention to provide a magnetic-disk glass substrate manufacturing method that can more reliably prevent adhesion of dust to a magnetic-disk glass substrate in the course of a packaging operation and a change in the state of surfaces of the magnetic-disk glass substrate.

To resolve the above problems, a magnetic-disk glass substrate manufacturing method according to an aspect of the present invention is characterized by placing a magnetic-disk glass substrate in a case, adsorbing, when storing the case into a packaging bag, dust floating in air by a charging device charged with static electricity, thereby removing it from an atmosphere of a packaging operation, storing the case with the magnetic-disk glass substrate

placed therein into the packaging bag, and sealing the packaging bag in a degassed state.

According to the above manufacturing method, in the packaging operation of placing the magnetic-disk glass substrate into the packaging bag, the dust floating in the atmosphere of the packaging operation is adsorbed and removed by the charging device and, therefore, it becomes possible not only to reduce the dust that adheres to the magnetic-disk glass substrate, but also to reduce the dust included in the packaging bag.

Therefore, in the course of the operation of packaging the magnetic-disk glass substrate, it is possible to prevent the dust floating in the air from adhering to the magnetic-disk glass substrate and, therefore, it is possible to provide the magnetic-disk glass substrate with no influence of the dust on the surfaces thereof.

It may be that charged particles are charged from a charged particle discharge device into the dust floating in the air, thereby charging the dust, and the charging device is charged with a polarity opposite to that of the dust discharged with the charged particles.

By the above manufacturing method, when the charged particles are discharged from the charged particle discharge device into the dust floating in the air, all the dust regardless of having a positive, negative, or neutral polarity comes to have the same polarity corresponding to a polarity of the charged particles discharged from the charged particle discharge device. Therefore, for example, by causing the charging device to have the positive polarity, it becomes possible to adsorb the dust whose polarity has been made negative by the charged particles.

A bias voltage may be applied to the magnetic-disk glass substrate to charge the magnetic-disk glass substrate with the same polarity as that of the dust. By causing the magnetic-disk glass substrate to have the same polarity

as that of the dust, the magnetic-disk glass substrate can repel the dust to prevent adsorption thereof.

The magnetic-disk glass substrate may be used for manufacturing a magnetic disk that is recorded using a DFH head.

Since the magnetic-disk glass substrate manufactured by the above manufacturing method has a reduced amount of particles as compared with a magnetic-disk glass substrate manufactured by a conventional manufacturing method, the smoothness and flatness of the main surfaces of the glass substrate are high. Therefore, the magnetic-disk glass substrate according to this invention is suitably used for a magnetic disk that is recorded in a magnetic recording system using a DFH head whose flying height is low.

The magnetic-disk glass substrate is adapted to be used for manufacturing a magnetic disk over which a flying height of a magnetic head is 10nm or less in recording on the magnetic disk.

The smoothness and flatness of the main surfaces of the magnetic-disk glass substrate manufactured by the above manufacturing method are high. Therefore, a magnetic disk manufactured using such a glass substrate can be adapted to a recording system in which the flying height of a magnetic head is 10nm or less.

The magnetic-disk glass substrate is adapted to be used for manufacturing a magnetic disk with a recording density of 200Gbit/inch² or more.

As described above, the smoothness and flatness of the main surfaces of the magnetic-disk glass substrate manufactured by the manufacturing method according to one configuration of this invention are high. Therefore, a magnetic disk manufactured using such a glass substrate can be suitably applied to a magnetic disk with a recording density of 200Gbit/inch² or more whose high recording density is achieved by a recording system in which the

flying height of a magnetic head is low.

Brief Description of the Drawings

Fig. 1 shows diagrams for explaining a magnetic-disk glass substrate according to an embodiment of this invention.

Fig. 2 is an explanatory diagram of the flow from placing magnetic-disk glass substrates into magnetic-disk glass substrate cases until packaging the magnetic-disk glass substrate cases.

Fig. 3 shows diagrams for explaining a state where magnetic-disk glass substrates are placed in cases.

Fig. 4 is a schematic diagram of a device for removing dust.

Fig. 5 is a diagram for explaining a packaged state of the cases with the magnetic-disk glass substrates placed therein.

Fig. 6 is a diagram counting the number of dust particles by unpackaging a package with dust removed being an Example of this invention and a package with dust not removed being a Comparative Example.

Description of the Embodiment of the Invention

First, a magnetic-disk glass substrate manufacturing method according to an embodiment of this invention will be described. Fig. 1 shows diagrams for explaining a magnetic-disk glass substrate according to this embodiment, wherein Fig. 1(a) is a perspective view of the magnetic-disk glass substrate. The magnetic-disk glass substrate 100 has a disk shape with an inner hole formed at the center thereof. Each of main surfaces 110 is a region for recording/reproducing information and thus is substantially smooth for allowing a recording head to fly thereover.

Fig. 1(b) is an X-X sectional view of Fig. 1(a). The magnetic-disk glass substrate 100 comprises the main surfaces 110 that will serve as information

recording/reproducing regions, an end face 120 perpendicular to the main surfaces 110, and chamfered faces 130 interposed between the main surfaces 110 and the end face 120, respectively. Since it may happen that the boundary between the end face 120 and each chamfered face 130 becomes unclear by a later-described end face polishing process, this embodiment also includes a case where the end face 120 and the chamfered faces 130 on both sides thereof cooperatively form one curved surface.

If particles or foreign matter adheres to the magnetic-disk glass substrate 100, particularly to the main surfaces 110 thereof, before a magnetic-disk film forming process, smooth magnetic layers cannot be formed on the magnetic-disk glass substrate in the film forming process and thus the yield rate of magnetic disks as final products decreases. Therefore, a description will be given of a magnetic-disk glass substrate manufacturing method adapted to prevent adhesion of particles or foreign matter to the glass substrate.

(Magnetic-Disk Glass Substrate Manufacturing Method)

Subsequently, a description will be given of the flow from placing magnetic-disk glass substrates 100 into magnetic-disk glass substrate cases until packaging the magnetic-disk glass substrate cases.

Fig. 2 is an explanatory diagram of the flow from placing the magnetic-disk glass substrates 100 into the magnetic-disk glass substrate cases until packaging the magnetic-disk glass substrate cases. Fig. 3 shows diagrams for explaining a state where the magnetic-disk glass substrates are placed in the cases. Fig. 4 is a schematic diagram of a device for removing dust.

First, in order to facilitate transportation of the magnetic-disk glass substrates 100, the magnetic-disk glass substrates 100 are placed into the cases (S200). Herein, the case for placing the magnetic-disk glass substrates

therein will be described.

Fig. 3(a) is an enlarged view of the generally rectangular parallelepiped magnetic-disk glass substrate case serving as a container for storing the magnetic-disk glass substrates. The case 300 is capable of accommodating one or a plurality of magnetic-disk glass substrates and the magnetic-disk glass substrates 100 are stored in the case 300. A plurality of, for example, four, cases 300 with the magnetic-disk glass substrates 100 placed therein are arranged side by side as shown in Fig. 3(b) and are, in this state, placed in a packaging bag.

The magnetic-disk glass substrates 100 are placed in the case 300 and, from dust 310 floating in air as shown in Fig. 4, the dust having a negative polarity is adsorbed by a single or a plurality of charging devices 320 caused to have a positive polarity (S210). Herein, in a room or the like where the dust 310 is adsorbed using the charging device 320, it is possible to produce a flow of air (convection) by a fan (not illustrated) or the like to cause the air to flow toward the charging device 320, thereby adsorbing the dust 310.

By causing the charging device 320 to have the polarity, the dust 310 having the opposite polarity is adsorbed and thus the number of dust particles 310 floating in the air is reduced.

However, not all the dust 310 has the negative polarity. There exist the dust having a positive polarity and the neutral dust with no polarity. In view of this, for example, in order to make negative the polarity of the dust 310 floating in the air, a charged particle discharge device 330 is used to discharge, into the air, charged particles that serve to make negative the polarity of the dust 310 (S220).

With the above configuration, when the charged particles are discharged from the charged particle discharge device 330 into the dust 310 floating in the air, all the dust 310 regardless of having the positive, negative, or

neutral polarity comes to have the same polarity corresponding to the polarity of the charged particles discharged from the charged particle discharge device 330. Therefore, for example, by causing the charging device 320 to have the positive polarity, it adsorbs the dust 310 whose polarity has been made negative by the charged particles.

Further, in order to prevent the dust 310 from being adsorbed onto the magnetic-disk glass substrates 100, a magnetic-disk glass substrate charging device 340 of Fig. 4 is attached for applying a bias voltage to the magnetic-disk glass substrates 100 to charge them negative, i.e. the same polarity as that of the dust. Accordingly, the magnetic-disk glass substrate charging device 340 causes the magnetic-disk glass substrates 100 to have the same polarity as that of the dust 310 (S230).

By causing the magnetic-disk glass substrates 100 to have the same polarity as that of the dust 310, the magnetic-disk glass substrates 100 repel the dust 310 to prevent adsorption thereof.

By carrying out these operations, the dust 310 is not adsorbed onto the magnetic-disk glass substrates 100, but is removed by the charging device 320 (S240). Then, the magnetic-disk glass substrate charging device 340 is detached from the magnetic-disk glass substrates and, in the state where the dust 310 is removed, the cases are packaged with a packaging bag (S250).

Herein, Fig. 5 is a diagram for explaining a packaged state of the cases 300 with the magnetic-disk glass substrates 100 placed therein. In the state of being stacked together, the cases 300 with the magnetic-disk glass substrates 100 placed therein are sealed in a degassed state. The cases 300 are packaged with a degassed packaging bag 350, thereby forming a package 352.

According to the above configuration, in the packaging operation of placing the magnetic-disk glass substrates 100 into the packaging bag 350, the dust 310 floating in the atmosphere of the packaging operation is adsorbed and

removed by the charging device 320 and, therefore, not only the dust 310 that adheres to the magnetic-disk glass substrates 100, but also the dust 310 included in the packaging bag 350 is reduced.

The packaging bag 350 of the package 352 is unpackaged in another room (not illustrated). This another room is an intermediate room adjacent to a predetermined room and to a clean room in which the production line is provided, wherein an air flow is generated so as to be directed toward the predetermined room.

Hereinabove, the description has been made of the embodiment of the magnetic-disk glass substrate manufacturing method according to this invention. Since the subject magnetic-disk glass substrate has a reduced amount of dust as compared with a magnetic-disk glass substrate 100 manufactured by a conventional manufacturing method, the smoothness and flatness of the main surfaces of the glass substrate are high. Therefore, it can be used for a magnetic disk that is recorded in a recording system using a magnetic head with a low flying height, i.e. a recording system in which the flying height of a magnetic head is 10nm or less, and thus is required to have high smoothness and flatness. Further, from the same point of view, the subject magnetic-disk glass substrate is also suitably used for a magnetic disk that is recorded in a magnetic recording system using a DFH head whose flying height is low and, further, it can also be used for a magnetic disk with a recording density of 200Gbit/inch² or more whose high recording density has been achieved by a reduction in flying height of a magnetic head.

In addition, the smoothness of a magnetic disk manufactured using the subject glass substrate can satisfy a standard of a glide height of 10nm or less in a glide test. This is because since a glass substrate manufactured by the manufacturing method according to this invention has main surfaces with high smoothness and flatness, the smoothness and flatness of main surfaces of a

magnetic disk manufactured using the subject glass substrate are also improved.

(Example)

Hereinbelow, using an Example, a description will be given of a magnetic-disk glass substrate manufacturing method to which this invention is applied. Magnetic-disk glass substrates 100 to be packaged are intended to be manufactured as 2.5-inch disks. Alternatively, the glass substrates 100 may be manufactured as magnetic disks having a predetermined shape, such as 0.8-inch disks (inner diameter 6mm, outer diameter 21.7mm, thickness 0.381mm), 1.0-inch disks (inner diameter 7mm, outer diameter 27.4mm, thickness 0.381mm), or 1.8-inch magnetic disks (inner diameter 12mm, outer diameter 48mm, thickness 0.508mm). The glass substrates 100 may alternatively be applied to 3.5-inch disks.

(1) Shaping Process and First Lapping Process

In this embodiment, as a material of magnetic-disk glass substrates 100, there can be cited sodalime glass, aluminosilicate glass, borosilicate glass, crystallized glass, or the like. Among them, the aluminosilicate glass is preferable. Since the aluminosilicate glass can obtain smoothness and high rigidity, the magnetic spacing, particularly the flying height of a magnetic head, can be reduced more stably. Further, the aluminosilicate glass can obtain high rigidity and strength by chemical strengthening.

First, molten aluminosilicate glass was formed into a disk shape by direct pressing using upper, lower, and drum molds, thereby obtaining an amorphous plate-like glass. As the aluminosilicate glass, use was made of a glass for chemical strengthening. Other than the direct pressing, disk-shaped magnetic-disk glass substrates 100 may be obtained by cutting them out, using a grindstone, from a sheet glass formed by a downdraw method or a float method. As the aluminosilicate glass, use was made of a chemical

strengthening glass containing, as main components, SiO_2 : 58 to 75wt%, Al_2O_3 : 5 to 23wt%, Li_2O : 3 to 10wt%, and Na_2O : 4 to 13wt%.

Then, lapping was applied to both main surfaces of the plate-like glass, thereby obtaining a disk-shaped glass base member. The lapping was carried out using a double-side lapping machine employing a planetary gear mechanism with the use of alumina-based free abrasive grains. Specifically, the lapping was carried out by pressing lapping surface plates onto both surfaces of the plate-like glass from the upper and lower sides, supplying a grinding fluid containing the free abrasive grains onto the main surfaces of the plate-like glass, and relatively moving them to each other. By this lapping, there was obtained the glass base member having the flat main surfaces.

(2) Cutting-Out Process (Coring, Forming)

Then, the glass base member was cut using a diamond cutter, thereby cutting out disk-shaped magnetic-disk glass substrates from the glass base member. Then, using a cylindrical diamond drill, an inner hole was formed at a central portion of each magnetic-disk glass substrate, thereby obtaining annular magnetic-disk glass substrates 100 (coring). Then, grinding was applied to inner peripheral end faces and outer peripheral end faces 120 using diamond grindstones, thereby carrying out predetermined chamfering (forming).

(3) Second Lapping Process

Then, second lapping was applied to both main surfaces 110 of each of the obtained magnetic-disk glass substrates 100 in the same manner as in the first lapping process. By performing this second lapping process, minute irregularities formed on the main surfaces in the cutting-out process or an end face polishing process as a previous process can be removed in advance, so that it becomes possible to complete a subsequent polishing process of the main surfaces 110 in a short time.

(4) End Face Polishing Process

Then, outer peripheral end face polishing of the magnetic-disk glass substrates 100 was carried out. First, the end faces 120 were independently polished prior to chamfered faces 130. A polishing method may be, for example, a method of simultaneously polishing a plurality of the magnetic-disk glass substrates 100 using a brush, but the machining allowance becomes large. Therefore, use may be made of, for example, a single-wafer polishing method.

Subsequently, the chamfered faces 130 were mirror-polished. By this, the difference in surface roughness of the chamfered faces 130 of each magnetic-disk glass substrate 100 over the entire circumference fell within the range of $0.001\mu\text{m}$ or less. Then, the magnetic-disk glass substrates 100 having been subjected to the end face polishing process were washed with water. By this end face polishing process, the end faces 120 of the magnetic-disk glass substrates 100 were finished to a mirror surface state that can prevent precipitation of sodium and potassium.

In this Example, it has been described that the chamfered faces 130 were polished after the end faces were polished. However, this order is optional and it may be configured that the chamfered faces 130 are first polished and then the end faces 120 are polished.

Then, with respect to the inner peripheral end faces, it may be configured that a block is formed by stacking a number of the glass substrates and chamfered inner peripheral end portions are simultaneously polished using a brush roll. In this event, as polishing abrasive grains, use was made of a slurry (free abrasive grains) containing cerium oxide abrasive grains.

(5) Main Surface Polishing Process

A first polishing process was first carried out as a main surface polishing process. This first polishing process mainly aims to remove cracks or strains remaining on the main surfaces 110 during the above lapping processes. In

this first polishing process, the main surfaces 110 were polished using a double-side polishing machine having a planetary gear mechanism with the use of a hard resin polisher. Cerium oxide abrasive grains were used as a polishing material.

The magnetic-disk glass substrates 100 having been subjected to the first polishing process were immersed in respective cleaning baths of neutral detergent, pure water, and IPA (isopropyl alcohol) in turn so as to be cleaned.

Then, a second polishing process was carried out as a main surface polishing process. This second polishing process aims to finish the main surfaces 110 into mirror surfaces. In this second polishing process, the main surfaces 110 were mirror-polished using a double-side polishing machine having a planetary gear mechanism with the use of a soft resin foam polisher. As a polishing material, use was made of cerium oxide abrasive grains finer than the cerium oxide abrasive grains used in the first polishing process.

The magnetic-disk glass substrates 100 having been subjected to the second polishing process were immersed in respective cleaning baths of neutral detergent, pure water, and IPA (isopropyl alcohol) in turn so as to be cleaned. An ultrasonic wave was applied to each cleaning bath.

(6) Chemical Strengthening Process

Then, chemical strengthening was applied to the magnetic-disk glass substrates 100 having been subjected to the above lapping processes and polishing processes. The chemical strengthening was carried out by preparing a chemical strengthening solution in the form of a mixture of potassium nitrate (60%) and sodium nitrate (40%), heating this chemical strengthening solution to 400°C and preheating the cleaned magnetic-disk glass substrates 100 to 300°C, and immersing the magnetic-disk glass substrates 100 in the chemical strengthening solution for about 3 hours. In order to chemically strengthen the entire surfaces of the magnetic-disk glass substrates 100, the immersion was

carried out in the state where the magnetic-disk glass substrates 100 were placed in a holder so as to be held at their end faces 120.

By performing the immersion process in the chemical strengthening solution as described above, lithium ions and sodium ions in the surface layers of each magnetic-disk glass substrate 100 are replaced by sodium ions and potassium ions in the chemical strengthening solution, respectively, so that the magnetic-disk glass substrates 100 are strengthened. The thickness of a compressive stress layer formed in each surface layer of each magnetic-disk glass substrate 100 was about 100 μ m to 200 μ m.

The magnetic-disk glass substrates 100 having been subjected to the chemical strengthening process were immersed in a water bath at 20°C so as to be rapidly cooled, and maintained for about 10 minutes. Then, the rapidly cooled magnetic-disk glass substrates 100 were immersed in concentrated sulfuric acid heated to about 40°C, so as to be cleaned. Further, the magnetic-disk glass substrates 100 having been subjected to the sulfuric acid cleaning were immersed in respective cleaning baths of pure water and IPA (isopropyl alcohol) in turn so as to be cleaned. An ultrasonic wave was applied to each cleaning bath.

By performing the first lapping process, the cutting-out process, the end face polishing process, the second lapping process, the first and second polishing processes, and the chemical strengthening process as described above, there were obtained the flat, smooth, and high-rigidity magnetic-disk glass substrates 100.

(7) Inspection Process

Cleanness inspection was conducted for the main surfaces 110 of the obtained magnetic-disk glass substrates 100. Using a surface defect detection apparatus (AOI : Automatic Optical Inspection, OSA (Optical Surface Analyzer) or the like), the inspection process irradiates light onto the magnetic-disk glass

substrate 100, measures one or both of the intensity and displacement of light reflected from the magnetic-disk glass substrate 100 to determine whether or not adhering matter, a concave portion, or a convex portion exists, and evaluates the substrate state.

(8) Packaging Process

25 magnetic-disk glass substrates 100 were placed in each of cases 300 and the cases 300 in the number of four were arranged side by side. Then, the negative polarity was given to dust 310 floating in air, the magnetic-disk glass substrates 100 were caused to have the same polarity as that of the dust 310, and then the dust 310 was adsorbed and removed by a charging device 320. Then, the cases 300 with the magnetic-disk glass substrates 100 placed therein were put into a packaging bag 350 and this packaging bag 350 was sealed in a degassed state, thereby forming a package 352.

The package 352 in which the magnetic-disk glass substrates 100 were placed in the cases 300 and packaged with the packaging bag 350 as described above is shipped from a glass substrate manufacturing plant and transported to a magnetic disk manufacturing plant by a ship, an airplane, a train, or the like.

(9) Unpackaging Process

The packaging bag 350 of the package 352 was unpackaged in a predetermined room. Another room was adjacent to the predetermined room and to a clean room in which the production line was provided, wherein an air flow was generated so as to be directed toward the predetermined room (illustration of the predetermined room and the another room is omitted).

(10) Transfer-in Process

In order to perform a film forming process of forming magnetic layers on the magnetic-disk glass substrates 100, the magnetic-disk glass substrates 100

placed in the cases 200 were transferred into the clean room (illustration omitted) where the production line was provided.

(Evaluation)

A description will be given of effectiveness of this Example for the magnetic-disk glass substrates 100 unpackaged by the above processes. Fig. 6 is a diagram counting, using a surface defect detection apparatus (OSA6100), the number of dust particles by unpackaging the package 352 with dust removed being the Example and a package with dust not removed being a Comparative Example. Herein, three samples 410 of the Example (package with dust removed) and three samples 420 of the comparative Example (package with dust not removed) were arbitrarily selected. Then, the number of particles 430 such as the dust 310 adhering to the main surfaces of the three arbitrarily selected magnetic-disk glass substrates 100 for each was counted to derive the average number of particles 440 as the average of the three samples. The number of particles 430 was obtained by counting particles with a size of less than $1.0\mu\text{m}$. As a result, the average number of particles 440 of the samples 410 of the Example is about $1/3$ of, i.e. smaller than, the average number of particles 440 of the samples 420 of the Comparative Example and, therefore, there is observed a clear difference in the number of particles and thus there is obtained a result where the former shows high superiority as the packaging quality.

(11) Magnetic Disk Manufacturing Process (Film Forming Process)

This process is characterized by performing a film forming process of forming at least a magnetic layer on each of the magnetic-disk glass substrates 100 packaged using the above package.

On each of both surfaces of each of the magnetic-disk glass substrates 100 obtained through the packaging method and the manufacturing processes described above, an adhesive layer of a Cr alloy, a soft magnetic layer of a

CoTaZr-group alloy, an underlayer of Ru, a perpendicular magnetic recording layer of a CoCrPt-group alloy, a protective layer of hydrogenated carbon, and a lubricating layer of perfluoropolyether were formed in this order, thereby manufacturing perpendicular magnetic recording disks. This structure is one example of the structure of a perpendicular magnetic disk. Magnetic layers and so on may be formed as an in-plane magnetic disk.

As described above, according to the method of manufacturing the magnetic-disk glass substrates 100 in accordance with this embodiment, it is possible to more reliably prevent the dust 310 present in the packaging bag 350 and the cases 300 from adhering to the magnetic-disk glass substrates 100. Therefore, a magnetic disk manufactured using this magnetic-disk glass substrate 100 has a reduced number of convex defects and thus can achieve a reduction in flying height of a magnetic head to even 10nm or less and an increase in recording density to 200Gbit/inch² or more.

While the preferred embodiment of this invention has been described with reference to the accompanying drawings, it is needless to say that this invention is not limited thereto. It is obvious that a person skilled in the art can think of various changed examples or modified examples within the scope of claims and it is readily understood that those examples also belong to the technical scope of this invention.

Industrial Applicability

This invention is applicable to a magnetic-disk glass substrate manufacturing method.

CLAIMS

1. A magnetic-disk glass substrate manufacturing method characterized by
 - placing a magnetic-disk glass substrate in a case,
 - adsorbing, when storing said case into a packaging bag, dust floating in air by a charging device charged with static electricity, thereby removing it from an atmosphere of a packaging operation,
 - storing said case with said magnetic-disk glass substrate placed therein into said packaging bag, and
 - sealing said packaging bag in a degassed state.
 2. The magnetic-disk glass substrate manufacturing method according to claim 1, characterized by
 - discharging charged particles from a charged particle discharge device into the dust floating in the air, thereby charging the dust, and
 - charging said charging device with a polarity opposite to that of the dust discharged with said charged particles.
 3. The magnetic-disk glass substrate manufacturing method according to claim 1 or 2, characterized by applying a bias voltage to said magnetic-disk glass substrate to charge said magnetic-disk glass substrate with the same polarity as that of the dust.
-