

DESCRIPTION

[Title of Invention]

METHOD FOR MANUFACTURING GLASS SUBSTRATE FOR
5 INFORMATION RECORDING MEDIUM

[Technical Field]

[0001] The present invention relates to a method for manufacturing a glass substrate for an information recording medium.

10 [Background Art]

[0002] Conventionally, an aluminum substrate or a glass substrate has been used in an information recording medium (magnetic-disk recording medium) used in a computer or the like. A magnetic thin film layer is formed on the substrate and magnetized with a magnetic head, and thus information is
15 recorded in the magnetic thin film layer.

[0003] In recent years, recording density has been increasingly improved in hard disk drive (HDD) devices. Due to the improvement of recording density, a gap (flying height) between an information recording medium (medium) and a head that reads/writes records while flying above the information recording
20 medium has decreased to about several nanometers.

[0004] As the flying height decreases, problems such as a read error and/or a write error when accessing data recorded in a medium, and a head crash in which the magnetic head collides with the surface of a medium in the case where an information recording medium is used in a hard disk drive device are
25 more likely to occur. In order to suppress these problems, the size of defects on the surface of the substrate that are acceptable in an information recording medium has been further reduced. Accordingly, higher surface smoothness of a glass substrate for an information recording medium has been pursued, and various manufacturing methods have been devised to suppress foreign matter
30 adhering to the surface of the glass substrate and waviness in the surface of the

glass substrate.

[0005] On the other hand, in recent years, the storage capacity of an HDD has further increased. Nowadays, a 2.5-inch recording medium has been developed in which the recording density allows a storage capacity of 500 GB (250 GB on one side) and a surface recording density of equal to or greater than 630 Gbit per square inch.

[0006] In steps of manufacturing a glass substrate for an information recording medium, a step of polishing the surfaces of a glass substrate using a double-side polishing device is employed. For example, JP 2005-8353A (Patent Literature 1) describes usage of a jig having a special structure for collecting a polished glass substrate from a lower-side polishing pad mounted on a lower-side surface plate.

[Citation List]

[Patent Literature]

[0007] [PLT 1]: JP 2005-8353A

[Summary of Invention]

[Technical Problem]

[0008] When a polished glass substrate is to be removed from the lower-side polishing pad on the lower-side surface plate using the above-described jig, there are cases where the glass substrate is strongly attracted to the lower-side polishing pad. If the attraction force by which the lower-side polishing pad attracts the glass substrate is large, a large force is necessary to remove the glass substrate from the lower-side polishing pad, and therefore a removal instrument may be used, in which case there is a risk that dirt attributable to that instrument may newly adhere to the glass substrate.

[0009] Processing the glass substrate with the dirt adhering thereto into an information recording medium (magnetic disk) as it is leads to deterioration of recording characteristics.

[0010] The large force that is applied when removing the glass substrate from the lower-side polishing pad may act on the lower-side polishing pad and the

lower-side surface plate and damage the lower-side polishing pad and the lower-side surface plate.

[0011] The damage to the lower-side polishing pad and the lower-side surface plate may cause a defect such as a scratch on the glass substrate that is polished using these polishing pad and surface plate, leading to deterioration of the recording characteristics after the glass substrate is processed into an information recording medium. In a double-side polishing device, the same problem may occur with respect to an upper-side polishing pad and an upper-side surface plate as well.

[0012] The present invention was achieved in light of the aforementioned circumstances, and it is an object thereof to provide a method for manufacturing a glass substrate for an information recording medium, the method being capable of providing a glass substrate for an information recording medium that does not cause deterioration of the recording characteristics after being processed into an information recording medium.

[Solution to Problem]

[0013] A method for manufacturing a glass substrate for an information recording medium based on the present invention is a method for manufacturing a glass substrate for an information recording medium using a polishing device in which a polishing pad composed of a member containing a plurality of foam cells is mounted on a surface plate, and a surface of a glass substrate is polished using the polishing pad, the method including the following steps.

[0014] The method includes the steps of placing the glass substrate on the surface plate, polishing the surface of the glass substrate using the polishing device while supplying a liquid polishing agent to the glass substrate, and removing the polished glass substrate from the surface plate.

[0015] In a state in which the liquid polishing agent is supplied to the polishing pad, an attraction force of the polishing pad on the glass substrate is not less than 0.50 g/cm^2 and not more than 15 g/cm^2 .

[0016] According to another aspect, the polishing pad has a plurality of communication holes that allow adjacent foam cells of the foam cells to communicate with each other, and in a vertical section of the polishing pad taken in a direction of a normal to the surface plate, the communication holes
5 having a cross-sectional area of 0.01 mm^2 or more are present at a density of 30 or more communication holes per 25 mm^2 of the vertical section.

[0017] According to another aspect, in the vertical section of the polishing pad taken in the direction of the normal to the surface plate, the communication holes having a cross-sectional area of 0.01 mm^2 or more are present at a density
10 of 80 or more communication holes per 25 mm^2 of the vertical section.

[0018] According to another aspect, in the step of removing the polished glass substrate from the surface plate, the polished glass substrate is removed from the surface plate in a state in which the polishing pad still contains the liquid polishing agent.

[0019] According to another aspect, in the step of removing the polished glass substrate from the surface plate, the liquid polishing agent has a concentration that is 1.5-fold or more when compared with a concentration of the liquid polishing agent in the step of polishing the surface of the glass substrate using the polishing device.

[Advantageous Effects of the Invention]

[0020] According to the present invention, a method for manufacturing a glass substrate for an information recording medium is provided which is capable of providing a glass substrate for an information recording medium that does not cause deterioration of the recording characteristics after being processed into
25 an information recording medium.

[Brief Description of Drawings]

[0021] FIG. 1 is a perspective view showing a glass substrate for use in a magnetic disk.

FIG. 2 is a perspective view showing a magnetic disk including a glass
30 substrate.

FIG. 3 is a flowchart illustrating a method for manufacturing a glass substrate according to an embodiment.

FIG. 4 is a partial perspective view of a double-side polishing device that is used in a polishing step.

5 FIG. 5 is a flowchart illustrating a breakdown of a second polishing step of the method for manufacturing a glass substrate for an information recording medium according to the embodiment.

FIG. 6 is an enlarged vertical sectional view of a lower-side polishing pad of a background art.

10 FIG. 7 is an enlarged vertical sectional view of a lower-side polishing pad of the embodiment.

FIG. 8 shows the defect inspection results and the read/write test results with respect to Working Examples 1 to 5 and Comparative Examples 1 to 3.

15 [Description of Embodiments]

[0022] Hereinafter, an embodiment and examples based on the present invention will be described with reference to the drawings. When numbers, amounts, and so on are referred to in the following description of the embodiment and examples, the scope of the present invention is not necessarily
20 limited to those numbers, amounts, and so on, unless explicitly mentioned otherwise. In the following description of the embodiment and examples, identical or equivalent parts are denoted by identical reference numerals, and descriptions thereof may be omitted.

[0023] (Glass substrate 1 · magnetic disk 10)

25 First, a glass substrate 1 to be obtained by a method for manufacturing a glass substrate for an information recording medium based on the present embodiment as well as a magnetic disk 10 including the glass substrate 1 will be described with reference to FIGS. 1 and 2. FIG. 1 is a perspective view showing the glass substrate 1 for use in the magnetic disk 10 (see FIG. 2). FIG.
30 2 is a perspective view showing the magnetic disk 10 including the glass

substrate 1 and serving as an information recording medium.

[0024] As shown in FIG. 1, the glass substrate 1 (a glass substrate for an information recording medium) for use in the optical disk 10 has an annular disk shape in which a hole 1H is formed at the center. The circular, disk-shaped glass substrate 1 has a front main surface 1A, a back main surface 1B, an inner circumferential end surface 1C, and an outer circumferential end surface 1D.

[0025] The size of the glass substrate 1 is not particularly limited, and the outer diameter thereof may be, for example, 0.8 inches, 1.0 inch, 1.8 inches, 2.5 inches, or 3.5 inches. The thickness of the glass substrate 1 may be, for example, 0.30 mm to 2.2 mm in order to prevent breakage. The size of the glass substrate 1 according to the present embodiment is set so that it has an outer diameter of about 65 mm, an inner diameter of about 20 mm, and a thickness of about 0.8 mm. The thickness of the glass substrate 1 refers to a value that is calculated by averaging values measured at a plurality of arbitrary points on the glass substrate 1 that have point symmetry.

[0026] As shown in FIG. 2, in the magnetic disk 10, a magnetic film is formed on the aforementioned front main surface 1A of the glass substrate 1, thereby forming a magnetic thin film layer 2 including a magnetic recording layer. In FIG. 2, the magnetic thin film layer 2 is formed on only the front main surface 1A; however, the magnetic thin film layer 2 may also be formed on the back main surface 1B.

[0027] The magnetic thin film layer 2 is formed by spin-coating a thermosetting resin in which magnetic particles are dispersed on the front main surface 1A of the glass substrate 1 (spin-coating method). Alternatively, the magnetic thin film layer 2 may be formed on the front main surface 1A of the glass substrate 1 by a sputtering method, an electroless plating method, or the like.

[0028] The film thickness of the magnetic thin film layer 2 formed on the front main surface 1A of the glass substrate 1 may be about 0.3 μm to about 1.2 μm

in the case of the spin-coating method, about 0.04 μm to about 0.08 μm in the case of the sputtering method, and about 0.05 μm to about 0.1 μm in the case of the electroless plating method. From the viewpoint of making the film thinner and denser, it is preferable to form the magnetic thin film layer 2 by the sputtering method or the electroless plating method.

[0029] Magnetic materials used for the magnetic thin film layer 2 are not particularly limited, and conventionally known materials can be used. In order to provide high adhesion strength, it is preferable to use, for example, a Co-based alloy that contains Co, which has high crystal anisotropy, as a main component and to which Ni or Cr is added to adjust the residual magnetic flux density. FePt-based materials may also be used as materials for a magnetic layer that are preferable for thermally assisted recording.

[0030] In order to allow a magnetic recording head to slide smoothly, the surface of the magnetic thin film layer 2 may be thinly coated with a lubricant.

One example of the lubricant is a lubricant obtained by diluting perfluoropolyether (PFPE), which is a liquid lubricant, with a Freon-based solvent or the like.

[0031] In addition, a base layer and/or a protecting layer may be provided as needed. The base layer in the magnetic disk 10 is selected according to the magnetic film. For example, at least one selected from non-magnetic metals such as Cr, Mo, Ta, Ti, W, V, B, Al, or Ni can be used as a material for the base layer.

[0032] The base layer is not limited to a single layer, and may have a multilayer structure in which the same type or different types of layers are laminated. For example, the base layer may be a multilayer base layer made of Cr/Cr, Cr/CrMo, Cr/CrV, NiAl/Cr, NiAl/CrMo, NiAl/CrV, or the like.

[0033] Examples of the protecting layer for preventing wear and corrosion of the magnetic thin film layer 2 include a Cr layer, a Cr alloy layer, a carbon layer, a hydrogenated carbon layer, a zirconia layer, and a silica layer.

Together with the base layer, the magnetic film, and the like, the protecting

layer can be continuously formed using an inline-type sputtering device. The protecting layer may be a single layer or have a multilayer configuration constituted by the same type or different types of layers.

[0034] Another protecting layer may be formed on the above protecting layer or instead of the above protecting layer. For example, instead of the above protecting layer, a silicon oxide (SiO_2) layer may be formed by applying a solution obtained by diluting tetraalkoxysilane with an alcohol-based solvent and dispersing colloidal silica minute particles therein on a Cr layer, and by firing the Cr layer.

10 [0035] (Method for manufacturing glass substrate)

Next, a method for manufacturing a glass substrate for an information recording medium (hereinafter simply referred to as "glass substrate") according to the present embodiment will be described using a flowchart shown in FIG. 3. FIG. 3 is the flowchart illustrating the method for manufacturing the glass substrate 1 according to the present embodiment.

[0036] The method for manufacturing a glass substrate according to the present embodiment includes a glass blank material preparing step (step S10), a glass substrate forming/grinding step (step S20), a polishing step (step S30), a chemical strengthening step (step S40), and a cleaning step (step S50). A glass substrate (corresponding to the glass substrate 1 in FIG. 1) that is obtained through the chemical strengthening step (step S40) may also be subjected to a magnetic thin film forming step (step S60). The magnetic disk 10 serving as an information recording medium is obtained by the magnetic thin film forming step (step S60).

25 [0037] Hereinafter, details of the steps S10 to S60 will be described sequentially. In the following description, simplified cleaning that may be appropriately performed between the steps S10 to S60 is not described.

[0038] (Glass blank material preparing step)

In the glass blank material preparing step (step S10), a glass material constituting the glass substrate is melted (step S11). For example, common

aluminosilicate glass may be used as the glass material. Aluminosilicate glass contains 58 mass% to 75 mass% of SiO_2 , 5 mass% to 23 mass% of Al_2O_3 , 3 mass% to 10 mass% of Li_2O , and 4 mass% to 13 mass% of Na_2O as main components. The molten glass material is poured onto a lower mold and then
5 press molded using an upper mold and the lower mold (step S12). As a result of press molding, a disk-shaped glass blank material (glass base material) is formed.

[0039] The glass blank material may also be formed by cutting, with a grinding wheel, from sheet glass (plate glass) that is formed by a downdraw method or a
10 float method. Also, the glass material is not limited to aluminosilicate glass, and may be any material.

[0040] (Glass substrate forming/grinding step)

Next, in the glass substrate forming/grinding step (step S20), a first lapping step is applied to both main surfaces of the press molded glass blank
15 material for the purposes of improving the dimensional accuracy and the shape accuracy (step S21). The both main surfaces of the glass blank material refer to those main surfaces that constitute a front main surface 1A and a back main surface 1B, respectively, in FIG. 1 after undergoing the processes described below (hereinafter also referred to as "two main surfaces"). For example,
20 these main surfaces are finished to have a surface roughness R_{max} of about 6 μm using alumina abrasive grains of grain size #400 (grain diameter: about 40 to 60 μm).

[0041] After the first lapping step, a coring (inner circumference cutting) process is applied to a center portion of the glass blank material using a
25 cylindrical diamond drill or the like (step S22). An annular glass substrate having a hole at the center portion is obtained by the coring process. A predetermined chamfering process may optionally be applied to the hole at the center portion.

[0042] An inner circumferential end surface and an outer circumferential end
30 surface of the glass substrate are polished to a mirror finish with a brush (step

S22). A slurry containing cerium oxide abrasive grains may be used as polishing abrasive grains.

[0043] Next, a second lapping step is applied to the two main surfaces of the glass substrate (step S23). The second lapping step is performed using a double-side lapping device utilizing a planetary gear mechanism. Specifically, the second lapping step is performed by pressing surface plates against the two main surfaces of the glass blank material from the upper and lower sides, supplying water, a grinding liquid, or a lubricating liquid onto the two main surfaces of the glass substrate, and relatively moving the glass blank material and the lapping surface plates.

[0044] The substantial parallelism, flatness, thickness, and the like of the glass substrate are preliminarily adjusted by the second lapping step, and thus the glass substrate having the substantially flat main surfaces is obtained. In the second lapping step, finer abrasive grains than those in the above-described first lapping step are used in order to reduce the sizes of grinding marks that may be generated. For example, the two surfaces of the glass substrate may be finished to have a surface roughness R_{max} of about 2 μm by attaching fixed abrasive grains, such as a diamond tile pad, onto the surface plates.

[0045] (Polishing step)

Next, in the polishing step (step S30), as a first polishing step (rough polishing), warping of the glass substrate is eliminated while removing scratches that are left on the two main surfaces of the glass substrate after the above-described second lapping step (step S23) (step S31). In the first polishing step, a double-side polishing device utilizing a planetary gear mechanism is used. For example, polishing is performed using a polishing pad such as hard velour, polyurethane foam, or pitch-impregnated suede. A slurry serving as a liquid polishing agent and containing common cerium oxide abrasive grains as a main component may be used as a polishing agent. The substrate polished in the first polishing step is collected in a first-polishing removing step.

[0046] In a second polishing step (precision polishing), the glass substrate is again subjected to polishing, so that remaining small defects or the like on the two main surfaces of the glass substrate are eliminated (step S33). The two main surfaces of the glass substrate are mirror-finished and thus formed to have desired flatness, and warping of the glass substrate is also eliminated. In the second polishing step, a double-side polishing device utilizing a planetary gear mechanism is used. Polishing is performed using, for example, a suede pad, which is a soft polisher made of polyurethane foam, as a polishing pad. A slurry containing common colloidal silica, which is finer than cerium oxide used in the first polishing step, as a main component and serving as a liquid polishing agent is used as a polishing agent.

[0047] Here, a schematic configuration of a double-side polishing device 2000 will be described with reference to FIG. 4. FIG. 4 is a partial perspective view of the double-side polishing device 2000 that is used in the polishing step.

[0048] The double-side polishing device 2000 includes an upper surface plate (upper-side grindstone holding surface plate) 300, a lower surface plate (lower-side grindstone holding surface plate) 400, an upper-side polishing pad 310 attached to a lower surface of the upper surface plate 300, which is located on the side opposing the lower surface plate 400 (the side of the glass substrate), and a lower-side polishing pad 410 that is attached to an upper surface of the lower surface plate 400, which is located on the side opposing the upper surface plate 300 (the side of the glass substrate).

[0049] The upper-side polishing pad 310 and the lower-side polishing pad 410 are processing members for polishing the two main surfaces of the glass substrate 1. The upper surface plate 300 and the lower surface plate 400 are configured so as to rotate in directions opposite to the revolving direction of carriers 500. The surface of the upper-side polishing pad 310 that opposes the lower surface plate 400 forms a polishing surface 311 on the upper side. The surface of the lower-side polishing pad 410 that opposes the upper surface plate 300 forms a polishing surface 411 on the lower side. The carriers 500 are

arranged in a gap that is formed between the upper surface plate 300 and the lower surface plate 400. Each of these carriers 500 holds a plurality of disk-shaped glass substrates 1.

[0050] The glass substrates 1 are sandwiched between the upper surface plate 300 and the lower surface plate 400, and stress is applied in a thickness direction of the glass substrates by the upper surface plate 300 and the lower surface plate 400. Thus, the two main surfaces of each glass substrate are pressed against the polishing surface 311 of the upper-side polishing pad 310 and against the polishing surface 411 of the lower-side polishing pad 410. In this state, the polishing surface 311 of the upper-side polishing pad 310 is moved relative to one of the main surfaces of the glass substrate, thereby polishing this main surface. At the same time, the polishing surface 411 of the lower-side polishing pad 410 is moved relative to the other main surface of the glass substrate, thereby polishing the other main surface. In this manner, the two main surfaces of the glass substrate are simultaneously polished using the double-side polishing device 2000.

[0051] After precision polishing using the double-side polishing device, the glass substrates 1 adhering to the polishing surface 311 of the upper-side polishing pad 310 and the polishing surface 411 of the lower-side polishing pad 410 are removed from the polishing pads. The removal of the glass substrates from the polishing pads will be described later.

[0052] (Chemical strengthening step)

After the glass substrates 1 are cleaned, chemical strengthening layers are formed on the two main surfaces of each glass substrate 1 by immersing the glass substrate 1 in a chemical strengthening treatment solution (step S40). After the glass substrates 1 are cleaned, chemical strengthening is performed by immersing the glass substrates 1 in a chemical strengthening treatment solution such as a mixed solution of potassium nitrate (70%) and sodium nitrate (30%) that is heated to 300°C, for about 30 minutes.

[0053] Alkali metal ions, such as lithium ions and sodium ions, contained in

the glass substrates 1 are substituted for alkali metal ions, such as potassium ions, that have larger ionic radii than the former (ion exchange method).

[0054] Distortion that is caused by the different ionic radii generates compressive stress in an ion-exchanged region, and thus the two main surfaces of each glass substrate 1 are strengthened. For example, the rigidity of the glass substrate 1 may be improved by forming a chemical strengthening layer in each of the two main surfaces of the glass substrate 1 to a depth of about 5 μm from the surface of the glass substrate 1. A glass substrate corresponding to the glass substrate 1 shown in FIG. 1 is obtained in the above-described manner.

[0055] The glass substrate 1 may optionally be subjected to a further polishing process in which the removal amount on the two main surfaces is not less than 0.1 μm and not more than 0.5 μm . Deposits remaining on the main surfaces of the glass substrate 1 after the chemical strengthening step are removed, and thus the occurrence of a head crash into a magnetic disk that is manufactured using the glass substrate 1 is reduced. Setting the removal amount on the two main surfaces in the polishing process to not less than 0.1 μm and not more than 0.5 μm also prevents nonuniformity of the stress that is caused by the chemical strengthening treatment from appearing on the surfaces. The method for manufacturing a glass substrate according to the present embodiment is configured as described above.

[0056] The chemical strengthening step may be performed between the first polishing step (rough polishing) and the second polishing step (precision polishing).

[0057] (Cleaning step)

Next, the glass substrate is cleaned (step S50). The two main surfaces of the glass substrate 1 are cleaned with a detergent, pure water, ozone, IPA (isopropyl alcohol), UV (ultraviolet) ozone, or the like, and thus deposits deposited on the two main surfaces of the glass substrate 1 are removed.

[0058] After that, the number of residual deposits on the surfaces of the glass

substrate 1 is inspected using an optical defect inspection device or the like.

[0059] (Magnetic thin film forming step)

A magnetic film is formed on the two main surfaces (or either one of the main surfaces) of the glass substrate (corresponding to the glass substrate 1 shown in FIG. 1) with respect to which the chemical strengthening treatment has been finished, and thus the magnetic thin film layer 2 is formed. The magnetic thin film layer 2 is formed by sequentially forming an adhesive layer made of a Cr alloy, a soft magnetic layer made of a CoFeZr alloy, an orientation-controlling base layer made of Ru, a perpendicular magnetic recording layer made of a CoCrPt alloy, a C-based protecting layer, and an F-based lubricating layer. A perpendicular magnetic recording disk corresponding to the magnetic disk 10 shown in FIG. 2 can be obtained by the formation of the magnetic thin film layer 2.

[0060] The magnetic disk according to the present embodiment is an example of a perpendicular magnetic disk composed of a magnetic thin film layer. The magnetic disk may also be composed of a magnetic layer and the like as a so-called longitudinal magnetic disk.

[0061] (Second polishing step S33)

Now, details of the second polishing step S33 will be described with reference to FIGS. 5 to 7. FIG. 5 is a flowchart illustrating a breakdown of the second polishing step S33, FIG. 6 is an enlarged vertical sectional view of a lower-side polishing pad 410 of a background art, and FIG. 7 is an enlarged vertical sectional view of the lower-side polishing pad 410 of the present embodiment. Although the lower-side polishing pad and the lower-side surface plate are mainly described below, the same applies to the upper-side polishing pad and the upper-side surface plate.

[0062] Referring to FIG. 5, the second polishing step S33 has a carrier arranging step (S331), a glass substrate arranging step (S332), a polishing step (S333), a glass substrate removing step (S334), and a carrier removing step (S335).

[0063] Among these steps, with respect to the glass substrate removing step (S334), attraction of the glass substrate 1 to the lower-side polishing pad 410 has been a problem. This is attributed to usage of a polishing pad having a closed-cell structure, in which, as shown in FIG. 6, individual foam cells 410h are independent from adjacent foam cells 410h, or very few foam cells 410h communicate with adjacent foam cells 410h, as the lower-side polishing pad 410 of a background art.

[0064] Therefore, during the polishing step (S333), since the glass substrate 1 is pressed by the upper-side polishing pad 310 and the lower-side polishing pad 410 while being sandwiched therebetween, a phenomenon occurs in which the upper-side polishing pad 310 and the lower-side polishing pad 410 (especially the lower-side polishing pad 410 that is located on the lower side) strongly attract the glass substrate 1 (attraction force indicated by arrows S2 in FIG. 6).

[0065] On the other hand, FIG. 7 shows an enlarged view of the lower-side polishing pad 410 of the present embodiment. A polishing pad having an open-cell structure rather than a closed-cell structure is used as the lower-side polishing pad 410 of the present embodiment. Accordingly, in this lower-side polishing pad 410, communication holes 410c are formed that allow adjacent foam cells 410h to communicate with each other. A specific example of the material for this polishing pad is a suede pad made of polyurethane foam and formed by a wet coagulation method.

[0066] When the open-cell structure is employed for the lower-side polishing pad 410 as described above, a flow of the slurry and a flow of air (left-right arrows in FIG. 7) are generated between adjacent foam cells 410h, so that the attraction force of the lower-side polishing pad 410 on the glass substrate 1 (attraction force indicated by arrows S1 in FIG. 7) can be reduced.

[0067] Here, in the polishing step (S333), in which the slurry is supplied to the lower-side polishing pad 410, the attraction force of the lower-side polishing pad 410 on the glass substrate 1 is preferably not less than 0.50 g/cm^2 and not more than 15 g/cm^2 .

[0068] If the attraction force is less than 0.50 g/cm^2 , sliding between the glass substrate 1 and the polishing pad becomes too smooth to expect the polishing pad to polish the surface of the glass substrate 1. If the attraction force is more than 15 g/cm^2 , the force that is to be applied when removing the glass substrate 1 from the lower-side polishing pad 410 becomes excessively large (attraction force is excessively large).

[0069] In the lower-side polishing pad 410, in a vertical section (section shown in FIG. 7) of the lower-side polishing pad 410 taken in the direction of a normal to the lower surface plate 400, communication holes 410c having a cross-sectional area S of 0.01 mm^2 or more can be present at a density of 30 or more communication holes per 25 mm^2 of that vertical section. The attraction force of the lower-side polishing pad 410 on the glass substrate 1 can thus be set within the above-described range.

[0070] Preferably, it is preferable that in the vertical section of the lower-side polishing pad 410, communication holes 410c having a cross-sectional area S of 0.01 mm^2 or more are present at a density of 80 or more communication holes per 25 mm^2 of that vertical section. The attraction force of the lower-side polishing pad 410 on the glass substrate 1 can thus be set within a more preferable range.

[0071] In the glass substrate removing step (S334), it is preferable to remove the polished glass substrate 1 from the lower surface plate 400 in a state in which the lower-side polishing pad 410 still contains the slurry. With the background art, cleaning for washing away the slurry has been performed after the polishing step (S333). However, it was found that this cleaning increases the attraction force of the lower-side polishing pad 410 on the glass substrate 1. In the present embodiment, cleaning of the glass substrate 1 and the lower-side polishing pad 410 is performed after the glass substrate removing step (S334).

[0072] Furthermore, it is preferable that the concentration of the slurry in the glass substrate removing step (S334) is 1.5-fold or more when compared with the concentration in the polishing step (S333) using the double-side polishing

device 2000. The attraction force of the lower-side polishing pad 410 on the glass substrate 1 in the glass substrate removing step (S334) can thus be reduced even further. Specifically, a new slurry can be added in the glass substrate removing step (S334).

5 [0073] (Examples)

Hereinafter, examples based on the present embodiment will be described with reference to FIG. 8. FIG. 8 shows the defect inspection results and the read/write test results with respect to Working Examples 1 to 5 and Comparative Examples 1 to 3. In all of Working Examples 1 to 5 and
10 Comparative Examples 1 to 3, the steps shown in FIG. 3 are employed before the first polishing step (S31).

[0074] In all of the examples, the concentration of the slurry used in the polishing step (S333) of the second polishing step (S33) was set at 15 wt%. The glass substrate removing step (S334) was performed under eight different
15 conditions (Working Examples 1 to 5 and Comparative Examples 1 to 3) shown in FIG. 8 with respect to the polishing pads (upper-side polishing pad 310 and lower-side polishing pad 410) used and the state of the slurry after the end of the polishing step (S333).

[0075] In Working Example 1 and Comparative Example 1, a cleaning step
20 was performed after the end of the polishing step (S333) and before the glass substrate removing step (S334).

[0076] In Working Examples 2 and 3, a slurry having a high concentration was sprayed onto the polishing pads after the end of the polishing step (S333) and before the glass substrate removing step (S334) so that the slurry concentration,
25 which was 15 wt% at the beginning of the polishing step (S333), was increased at the beginning of the glass substrate removing step (S334).

[0077] In each of the working examples and comparative examples, the attraction force was measured by placing a test piece having substantially the same shape and the same surface roughness as the glass substrate on the
30 lower-side polishing pad immediately after the polishing step (S333), applying

a pressure equal to that in the polishing step to the test piece, then pulling up the test piece, and measuring the attraction force using a digital dynamometer. [0078] After the end of the second polishing step (S33), in all of the working examples and comparative examples, the glass substrate 1 was subjected to the chemical strengthening step (S40) and the cleaning step (S50), and then inspection for surface defects was performed. The defect inspection was performed using an optical defect inspection device Candela-OSA6100 manufactured by KLA-Tencor as a testing device.

[0079] In the defect inspection, 100 glass substrates that were processed in each of the working examples and comparative examples were 100-percent inspected, and substrates that were determined to have not more than 10 deposits and not more than 2 scratches were determined to be non-defective. The case where the number of non-defective substrates was 95 or more was evaluated as A (excellent), the case where the number was less than 95 and not less than 90 was evaluated as B (good), the case where the number was less than 90 and not less than 85 was evaluated as C (passable), and the case where the number was less than 85 was evaluated as D (poor).

[0080] Furthermore, after the glass substrates were processed into information recording media (processing into medium) through the magnetic thin film forming step (S60), a read/write test was performed.

[0081] In the read/write test, with respect to 100 glass substrates (information recording media) that were processed in each of the examples under the different conditions as described above, a test for measuring magnetic recording characteristics was performed. The case where the number of substrates that had passed the test was 96 or more was evaluated as A (excellent), the case where the number was less than 96 and not less than 92 was evaluated as B (good), the case where the number was less than 92 and not less than 88 was evaluated as C (passable), and the case where the number was less than 88 was evaluated as D (failure).

[0082] (Working Example 1)

For the glass substrates of Working Example 1, the attraction force was 15.0 g/cm², the number of communication holes in each polishing pad was 35, the slurry was accumulated on the polishing pads in the glass substrate removing step (S334), and the concentration of the slurry at that time was 15 wt%. The cleaning step was performed after the end of the polishing step (S333) and before the glass substrate removing step (S334). With respect to Working Example 1, the evaluation result of the defect inspection was "B", and the evaluation result of the read/write test was "B". The number of communication holes in each polishing pad means the number of communication holes having a cross-sectional area S of 0.01 mm² or more that are present per 25 mm² of a vertical section of the lower-side polishing pad 410 and of the upper-side polishing pad 310 taken in the direction of a normal to the lower surface plate 400. The same applies hereinafter.

[0083] (Working Example 2)

For the glass substrates of Working Example 2, the attraction force was 14.5 g/cm², the number of communication holes in each polishing pad was 35, the slurry was accumulated on the polishing pads in the glass substrate removing step (S334), and the concentration of the slurry at that time was 20 wt%. No cleaning step was performed after the end of the polishing step (S333) and before the glass substrate removing step (S334). In Working Example 2, a slurry having a high concentration was sprayed onto the polishing pads after the end of the polishing step (S333) and before the glass substrate removing step (S334). With respect to Working Example 2, the evaluation result of the defect inspection was "B", and the evaluation result of the read/write test was "B".

[0084] (Working Example 3)

For the glass substrates of Working Example 3, the attraction force was 13.0 g/cm², the number of communication holes in each polishing pad was 35, the slurry was accumulated on the polishing pads in the glass substrate removing step (S334), and the concentration of the slurry at that time was 25

wt%. No cleaning step was performed after the end of the polishing step (S333) and before the glass substrate removing step (S334). In Working Example 3, a slurry having a high concentration was sprayed onto the polishing pads after the end of the polishing step (S333) and before the glass substrate removing step (S334). With respect to Working Example 3, the evaluation result of the defect inspection was "A", and the evaluation result of the read/write test was "A".

[0085] (Working Example 4)

For the glass substrates of Working Example 4, the attraction force was 14.0 g/cm², the number of communication holes in each polishing pad was 63, the slurry was accumulated on the polishing pads in the glass substrate removing step (S334), and the concentration of the slurry at that time was 15 wt%. No cleaning step was performed after the end of the polishing step (S333) and before the glass substrate removing step (S334). With respect to Working Example 4, the evaluation result of the defect inspection was "B", and the evaluation result of the read/write test was "B".

[0086] (Working Example 5)

For the glass substrates of Working Example 5, the attraction force was 13.0 g/cm², the number of communication holes in each polishing pad was 88, the slurry was accumulated on the polishing pads in the glass substrate removing step (S334), and the concentration of the slurry at that time was 15 wt%. No cleaning step was performed after the end of the polishing step (S333) and before the glass substrate removing step (S334). With respect to Working Example 5, the evaluation result of the defect inspection was "A", and the evaluation result of the read/write test was "A".

[0087] (Comparative Example 1)

For the glass substrates of Comparative Example 1, the attraction force was 17.5 g/cm², the number of communication holes in each polishing pad was 24, and the slurry was not accumulated on the polishing pads in the glass substrate removing step (S334). A cleaning step was performed after the end

of the polishing step (S333) and before the glass substrate removing step (S334). With respect to Comparative Example 1, the evaluation result of the defect inspection was "D", and the evaluation result of the read/write test was "D".

[0088] (Comparative Example 2)

5 For the glass substrates of Comparative Example 2, the attraction force was 17.0 g/cm², the number of communication holes in each polishing pad was 24, the slurry was accumulated on the polishing pads in the glass substrate removing step (S334), and the concentration of the slurry at that time was 15 wt%. No cleaning step was performed after the end of the polishing step
10 (S333) and before the glass substrate removing step (S334). With respect to Comparative Example 2, the evaluation result of the defect inspection was "D", and the evaluation result of the read/write test was "D".

[0089] (Comparative Example 3)

 For the glass substrates of Comparative Example 3, the attraction force
15 was 16.0 g/cm², the number of communication holes in each polishing pad was 35, and the slurry was not accumulated on the polishing pads in the glass substrate removing step (S334). No cleaning step was performed after the end of the polishing step (S333) and before the glass substrate removing step (S334). With respect to Comparative Example 3, the evaluation result of the defect
20 inspection was "C", and the evaluation result of the read/write test was "C".

[0090] From the above-described evaluation results based on the attraction force with respect to Working Examples 1 to 5 and Comparative Examples 1 to 3, it was confirmed that in a wet state in which a slurry is supplied to the polishing pads, the attraction force of each polishing pad on the glass substrate
25 1 is preferably not less than 0.50 g/cm² and not more than 15 g/cm².

[0091] From the evaluation results based on the number of communication holes with respect to Working Examples 1 to 5 and Comparative Examples 1 to 3, it was confirmed that in a vertical section of each polishing pad taken in the direction of a normal to the corresponding surface plate, the communication
30 holes 410c having a cross-sectional area S of 0.01 mm² or more are preferably

present at a density of 30 or more communication holes per 25 mm² of the vertical section, and it was confirmed from Working Example 5 that the density is more preferably 80 or more communication holes.

[0092] From the evaluation results based on the number of communication holes with respect to Working Examples 1 to 5 and Comparative Examples 1 to 3, it was confirmed that in a vertical section of each polishing pad taken in the direction of a normal to the corresponding surface plate, the communication holes 410c having a cross-sectional area S of 0.01 mm² or more are preferably present at a density of 30 or more communication holes per 25 mm² of the vertical section, and it was confirmed from Working Example 5 that the density is more preferably 80 or more communication holes.

[0093] In Working Example 1, the cleaning step was performed after the end of the polishing step S333 and before the glass substrate removing step S334, while in Comparative Example 3, no cleaning step was performed after the end of the polishing step S333 and before the glass substrate removing step S334. Based on this, it was confirmed that it is better to remove the polished glass substrate 1 from the surface plates in a state in which the polishing pad still contains the slurry.

[0094] In Working Example 3, the slurry having a high concentration was sprayed onto the polishing pads after the end of the polishing step S333 and before the glass substrate removing step S334 so that the concentration of the slurry, which was 15 wt% at the beginning of the polishing step S333, was increased to 1.5-fold or more at the beginning of the glass substrate removing step S334. It was thus confirmed that the concentration of the slurry in the step of removing the polished glass substrate 1 from the surface plates is preferably 1.5-fold or more when compared with the concentration of the slurry in the step of polishing the surfaces of the glass substrate 1.

[0095] Although the case where a double-side polishing device is used has been described in the foregoing embodiment and examples, the present invention is not limited to a double-side polishing device.

[0096] While the embodiment and examples of the present invention have been described above, the disclosed embodiment and examples are to be considered in all respects as illustrative and not restrictive. The scope of the present invention is defined by the scope of the appended claims, and all changes that
5 come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

[List of Reference Numerals]

[0097] 1: Glass substrate, 1A: Front main surface, 1B: Back main surface, 1C: Inner circumferential end surface, 1D: Outer circumferential end surface, 1H:
10 Hole, 2: Magnetic thin film layer, 10: Magnetic disk, 300: Upper surface plate (upper-side grindstone holding surface plate), 310: Upper-side polishing pad, 311 and 411: Polishing surface, 400: Lower surface plate (lower-side grindstone holding surface plate), 410: Lower-side polishing pad, 410c: Communication hole, 410h: Foam cell, 500: Carrier, 2000: Double-side polishing device.

CLAIMS

1. A polishing pad mounted on a surface plate of a polishing device and used for a polishing process, characterized in that

5 the polishing pad has a plurality of foam cells and a plurality of communication holes that allow adjacent foam cells of the foam cells to communicate with each other, and

10 in a section of the polishing pad taken in a direction normal to the surface plate, the communication holes having a cross-sectional area of 0.01 mm^2 or more are present at a density of 30 or more communication holes per 25 mm^2 of the section.

2. The polishing pad according to claim 1, wherein

the surface plate of the polishing device includes an upper surface plate and a lower surface plate,

15 an upper-side polishing pad is attached to the upper surface plate, a lower-side polishing pad is attached to the lower surface plate, and the polishing pad is used as the lower-side polishing pad.

20 3. A method for manufacturing a glass substrate for an information recording medium using a polishing device in which a polishing pad composed of a member containing a plurality of foam cells is mounted on a surface plate, and a surface of a glass substrate is polished using the polishing pad, the method comprising the steps of:

placing the glass substrate on the surface plate;

25 polishing the surface of the glass substrate using the polishing device while supplying a liquid polishing agent to the glass substrate; and

removing the polished glass substrate from the surface plate, wherein

at least a lower-side polishing pad of the polishing pad has an open-cell structure in which a plurality of communication holes that allow adjacent foam cells of the foam cells to communicate with each other are formed, and

30 in a section of the lower-side polishing pad taken in a direction of a normal to the surface plate, the communication holes having a cross-sectional area of 0.01 mm^2 or more are present at a density of 30 or more communication holes per 25 mm^2 .

4. The method for manufacturing a glass substrate for an information recording medium according to claim 3, wherein

5 in the section of the lower-side polishing pad taken in the direction of the normal to the surface plate, the communication holes having a cross-sectional area of 0.01 mm^2 or more are present at a density of 80 or more communication holes per 25 mm^2 .

10 5. The method for manufacturing a glass substrate for an information recording medium according to any one of claims 1 to 4, wherein

in the step of removing the polished glass substrate from the surface plate, the polished glass substrate is removed from the surface plate in a state in which the polishing pad still contains the liquid polishing agent.

15 6. The method for manufacturing a glass substrate for an information recording medium according to claim 5, wherein

20 in the step of removing the polished glass substrate from the surface plate, the liquid polishing agent has a concentration that is 1.5-fold or more when compared with a concentration of the liquid polishing agent in the step of polishing the surface of the glass substrate using the polishing device.

25 7. A method for manufacturing a substrate for an information recording medium using a polishing device in which a polishing pad composed of a member containing a plurality of foam cells is mounted on a surface plate, and a surface of a substrate is polished using the polishing pad, the method comprising the steps of:

placing the substrate on the surface plate;

polishing the surface of the substrate using the polishing device while supplying a liquid polishing agent to the substrate; and

removing the polished substrate from the surface plate, wherein

30 in a state in which the liquid polishing agent is supplied to the polishing pad, an attraction force of at least a lower-side polishing pad of the polishing pad on the substrate is not less than 0.50 g/cm^2 and not more than 15 g/cm^2 .

8. A method for manufacturing a substrate for an information recording medium using a polishing device in which a polishing pad composed of a member containing a plurality of foam cells is mounted on a surface plate, and a surface of a substrate is polished using the polishing pad, the method comprising the steps of:

placing the substrate on the surface plate;

polishing the surface of the substrate using the polishing device while supplying a liquid polishing agent to the substrate; and

removing the polished substrate from the surface plate, wherein

at least a lower-side polishing pad of the polishing pad has an open-cell structure in which a plurality of communication holes that allow adjacent foam cells of the foam cells to communicate with each other are formed,

in a section of the lower-side polishing pad taken in a direction of a normal to the surface plate, the communication holes having a cross-sectional area of 0.01 mm^2 or more are present at a density of 30 or more communication holes per 25 mm^2 , and

in a state in which the liquid polishing agent is supplied to the polishing pad, an attraction force of the lower-side polishing pad on the substrate is not less than 0.50 g/cm^2 and not more than 15 g/cm^2 .

9. A method for manufacturing a substrate for an information recording medium using a polishing device in which a polishing pad composed of a member containing a plurality of foam cells is mounted on a surface plate, and a surface of a substrate is polished using the polishing pad, the method comprising the steps of:

placing the substrate on the surface plate;

polishing the surface of the substrate using the polishing device while supplying a liquid polishing agent to the substrate; and

removing the polished substrate from the surface plate, wherein

at least a lower-side polishing pad of the polishing pad has an open-cell structure in which a plurality of communication holes that allow adjacent foam cells of the foam cells to communicate with each other are formed, and

in a section of the lower-side polishing pad taken in a direction of a normal to the surface plate, the communication holes having a cross-sectional area of 0.01 mm^2 or

more are present at a density of 30 or more communication holes per 25 mm².

10. The method for manufacturing a substrate for an information recording medium according to claim 9, wherein

5 in the section of the lower-side polishing pad taken in the direction of the normal to the surface plate, the communication holes having a cross-sectional area of 0.01 mm² or more are present at a density of 80 or more communication holes per 25 mm².

10 11. The method for manufacturing a substrate for an information recording medium according to any one of claims 7 to 10, wherein

in the step of removing the polished substrate from the surface plate, the polished substrate is removed from the surface plate in a state in which the polishing pad still contains the liquid polishing agent.

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12. The method for manufacturing a substrate for an information recording medium according to claim 11, wherein

in the step of removing the polished substrate from the surface plate, the liquid polishing agent has a concentration that is 1.5-fold or more when compared with a
20 concentration of the liquid polishing agent in the step of polishing the surface of the substrate using the polishing device.