

METHOD AND APPARATUS OF MANUFACTURING MAGNETIC RECORDING MEDIUM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method and apparatus of manufacturing a magnetic recording medium. In particular, the invention relates to a shift technique of an insulating substrate in a deposition process of a disk-like magnetic recording medium.

2. Description of the Related Art

As an external recording device of a computer, a device using a magnetic disk as a recording medium has been mostly used. A standard magnetic disk has an outer diameter of 2.5 to 3.5 inches.

A deposition process on a standard insulating substrate 2.5 to 3.5 in. in diameter for a magnetic disk is typically performed by one-substrate-processing. As a method of applying a bias voltage on the insulating substrate during deposition, for example, the following two methods are given. One is a method that a conductive film (typically, a base film)

is deposited on the insulating substrate while supporting a certain position in the insulating substrate by a support tool, then a portion for supporting the insulating substrate is shifted to a position being different from the supporting position in depositing the conductive film, thereby the bias voltage is applied on the insulating substrate via the support tool and the conductive film while supporting a portion on which the conductive film was deposited, by the supporting tool. The other is a method that a bias terminal is contacted to an end face of the insulating substrate after depositing the conductive film, thereby the bias voltage is directly applied on the insulating substrate.

A demand for a magnetic disk having a small diameter of 1.25 in. or less has gradually increased in recent years, and the magnetic disk is also manufactured using the same manufacturing method and manufacturing apparatus as in the standard magnetic disk. However, while deposition apparatus for the standard substrate 3.5 in. in diameter can be used to perform deposition on a small-diameter insulating substrate, using efficiency of a target to a product is bad, resulting in reduction in productivity.

When multiple-substrate-processing (for example, four-substrate-processing) of small-diameter substrates is

thus processed to improve productivity, since size of an objective product is small, and multiple insulating substrates are simultaneously processed, a method of shifting an insulating substrate proposed in JP-A-2001-216689 (U.S. counterpart Patent USP 6660089) or the like can not be carried out. Thus, in the case of multiple-substrate-processing, a manufacturing method that deposition is performed on an insulating substrate without applying the bias voltage on the substrate, or a manufacturing method that a base layer is deposited, then a product is removed from vacuum apparatus to shift and support the insulating substrate, and then deposition is performed again with the bias voltage being applied in the vacuum apparatus can be used.

SUMMARY OF THE INVENTION

However, the former method without application of the bias voltage is used, an electromagnetic conversion property as a major property of a product is reduced. On the other hand, the latter method, in which the insulating substrate is temporarily removed from the vacuum apparatus and shifted to a different position, then the bias voltage is applied, quality of the product may be deteriorated by particles induced when the substrate is taken in/taken out into/from the vacuum apparatus.

Thus, it is desirable to provide a method and apparatus of manufacturing a magnetic recording medium, in which even if the multiple-substrate-processing is performed for improving productivity, the reduction in property or the deterioration in quality may not be induced.

A mode of apparatus of an embodiment of the invention includes, in deposition apparatus for stacking a plurality of layers including a magnetic layer on the plurality of insulating substrates, a carrier of holding a plurality of insulating substrates, the carrier having a plurality of support members for supporting respective predetermined positions on the plurality of insulating substrates, and a shift mechanism of collectively changing positions on the plurality of insulating substrates supported by the plurality of support members to different positions by rotating the plurality of insulating substrates held by the carrier by a predetermined rotation angle, wherein the plurality of support members are electrically conductive, and electrically connected to a bias unit for applying a bias voltage on the plurality of insulating substrates.

In another mode of the apparatus of the embodiment of the invention, the plurality of insulating substrates have a disk-like shape and center holes respectively, the plurality

of support members have deformation portions to be elastically deformed and contact portions being set at one ends of the deformation portions for contacting to end faces of the insulating substrates; the shift mechanism has a plurality of first members of performing closing operation for holding the substrates from a side of the center holes of the plurality of insulating substrates, opening operation for releasing the insulating substrates, and rotation operation in a direction parallel to surfaces of the substrates, and a plurality of second members of performing supporting operation of supporting the insulating substrates by contacting the contacting portions to the end faces to transmit elastic force of deformation portions to the insulating substrates, and blocking operation of blocking elastic force of the deformation portions to the insulating substrates by separating the contact portions from the end faces, the first and second members being provided correspondingly to the plurality of insulating substrates, and has a plurality of cams provided on one rotational shaft, and a transmission mechanism of transmitting rotation of the cams to the plurality of first members and the plurality of second members; the cams and the transmission mechanism are configured to allow the closing operation, the blocking operation, the rotation operation by the predetermined rotation angle, and the supporting operation to be performed successively in accordance with rotation of the

shaft.

A still another mode of the apparatus of an embodiment of the invention is configured such that each of the plurality of first members has a first swinging member swinging with a predetermined swinging center as a center while being reciprocally biased at one end by the transmission mechanism, and a second swinging member of which one end is disposed facing a middle portion between the other end of the first swinging member and the swinging center, and the other end is disposed facing the other end of the first swinging member; the one end of the second member is connected to the middle portion by a tension spring, and both the other ends are inserted into the center hole; the second swinging member swings via the tension spring in accordance with swinging of the first swinging member, thereby the described, both the other ends approach each other to perform the opening operation, and the described, both the other ends are separated from each other to perform the closing operation, and as an interval between the described, both the other ends is changed, a middle position of the interval is offset, thereby the insulating substrates are displaced to be separated from the carrier in the closing operation.

A still another mode of the apparatus of an embodiment of the invention includes a mechanism of attaching or removing

the carrier, which attaches or removes a different carrier for holding a different insulating substrate being large compared with the plurality of insulating substrates.

A mode of a method of an embodiment of the invention includes a first step of supporting respective predetermined positions of the plurality of insulating substrates by a plurality of conductive support members to hold the substrates; a second step of depositing conductive layers on the held, plurality of insulating substrates respectively; a third step of rotating the plurality of insulating substrates, thereby collectively changing the positions on the plurality of insulating substrates supported by the plurality of support members from the predetermined positions to different positions at which the conductive layers were deposited; and a fourth step of stacking a plurality of layers including a magnetic layer on the conductive layer on each of the plurality of insulating substrates while a bias voltage is applied on the plurality of insulating substrates through the plurality of support members and the conductive layers.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a cross section view of a magnetic recording medium manufactured by apparatus and a method of manufacturing

a magnetic recording medium of an embodiment of the invention;

Fig. 2 shows a view showing a condition that four glass substrates are mounted on one small-diameter sputter carrier for special size of 3.5 inches;

Fig. 3 shows a view showing a condition that 3.5 in. sputter holder is mounted on the small-diameter sputter carrier for special size of 3.5 inches;

Fig. 4 shows a side view of a small-diameter substrate shift mechanism of the embodiment of the invention;

Fig. 5 shows a cross section view taken along V-V line of the small-diameter substrate shift mechanism of the embodiment of the invention;

Fig. 6 shows a cross section view taken along VI-VI line of the small-diameter substrate shift mechanism of the embodiment of the invention;

Fig. 7 shows a cross section view taken along VII-VII line of the small-diameter substrate shift mechanism of the embodiment of the invention;

Fig. 8 shows a cam chart showing substrate shift operation by the small-diameter substrate shift mechanism of the embodiment of the invention; and

Fig. 9 shows an operation state diagram in the substrate shift operation by the small-diameter substrate shift mechanism of the embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 shows a cross section view of a magnetic recording medium manufactured by apparatus and a method of manufacturing a magnetic recording medium, according to an embodiment of the invention.

A nonmagnetic insulating substrate 1, for which tempered glass, glass ceramics, or Si is used, is in a disk-like shape having a hole in the center. A seed layer (base layer) 2, nonmagnetic orientation control layer 3, nonmagnetic base layer 4, nonmagnetic intermediate layer 5, magnetic layer 6, passivation film 7, and liquid lubricant layer 8 are stacked on the nonmagnetic insulating substrate 1. A conductive material is used for the seed layer 2. The nonmagnetic orientation control layer 3, nonmagnetic base layer 4, or nonmagnetic intermediate layer 5 is sometimes changed in composition or number of layers for orientation control of the magnetic layer. For example, a thin film mainly containing carbon is used for the passivation film 7. For example, a perfluoropolyether series lubricant can be used for the liquid lubricant layer 8.

In the embodiment, multiple-substrate-processing (for example, 4-substrate-processing) of small-diameter substrate

is performed to deposit the respective layers 2 to 8 on tops of substrates. This is performed by depositing the seed layer (base layer) 2 on each nonmagnetic insulating substrate 1 in vacuum apparatus, then the substrate is shifted using a substrate shift device specific to the embodiment of the invention, and then depositing the respective layers 2 to 8 with a bias voltage being applied without taking in or taking out the substrate. The substrate shift device shifts the substrate to allow a holding position on the top of the substrate to be changed after depositing the seed layer, thereby a holding member (not shown) holds a deposited conductive portion on the top of the substrate, consequently the bias voltage can be applied from a bias circuit (not shown) to the seed layer 2 and the nonmagnetic insulating substrate 1 via the holding member.

Example

An example of four-substrate-processing is described in detail.

A small-diameter chemical-tempered glass substrate having a smooth surface is used as a nonmagnetic substrate, and subjected to texturing and then washed. As shown in Fig. 2, washed, four small-diameter chemical-tempered glass substrates 9 are mounted on one small-diameter sputter carrier

10 for special size of 3.5 inches. The small-diameter sputter carrier 10 for special size of 3.5 inches. has four holes each having one movable claw 11 for holding a small-diameter sputter carrier substrate and two stationary claws 12 for holding the small-diameter sputter carrier substrate. The movable claw 11 for holding the small-diameter sputter carrier substrate has a contact portion in an arch shape at a tip portion of a spring member being bent in an L-shape. The arch is perpendicular to a longitudinal direction of the spring member, and perpendicular to an edge of the small-diameter chemical-tempered glass substrate 9. Each of the stationary claws 12 for holding the small-diameter sputter carrier substrate has a contact portion in an arch shape at a tip portion. The contact portions of the stationary claws 12 for holding the small-diameter sputter carrier substrate support a lower portion of the small-diameter chemical-tempered glass substrate 9, and the contact portion of the movable claw 11 for holding the small-diameter sputter carrier substrate presses an upper portion of the small-diameter chemical-tempered glass substrate 9 by elastic force of the spring member of the movable claw 11, thereby the small-diameter chemically-reinforced glass substrate 9 is supported.

While four-substrate-processing is carried out in the

example, an embodiment of the invention can cope with multiple-substrate-processing of any number of substrates in an allowable range of a sputter cathode.

Next, the four small-diameter chemical-tempered glass substrates 9 are put into sputter apparatus (not shown) in a supported condition in Fig. 2 for simultaneous deposition of the four substrates. In the sputter apparatus, as shown in Fig. 3, a 3.5 in. sputter holder 13 is provided, and a 3.5 in. substrate holding claw 14 holds the small-diameter sputter carrier 10 for special size of 3.5 inches. Accordingly, the small-diameter sputter carrier 10 for special size of 3.5 in. can be mounted and removed, consequently it can be replaced with a different carrier. In a condition that the 3.5 in. sputter holder 13 is attached with the small-diameter sputter carrier 10 for special size of 3.5 inches, the movable claws 11 for holding the small-diameter sputter carrier substrate are electrically connected to a bias circuit 15.

In the sputter apparatus, the seed layer 2 is deposited at Ar gas pressure of 5 mTorr to 30 mTorr, then simultaneous shift of the four small-diameter chemical-tempered glass substrates 9 is performed by a shift mechanism as described later. As a result, the movable claw 11 for holding the small-diameter sputter carrier substrate, which has held an

insulating portion being not subjected to deposition, holds the seed layer 2 as a deposited conductive layer. Accordingly, in subsequent steps, a bias voltage can be applied from the bias circuit 15 to the seed layer 2 and nonmagnetic insulating substrate 1 via the movable claw 11 for holding the small-diameter sputter carrier substrate, which enables bias sputter.

Here, a configuration of a small-diameter substrate shift mechanism used for the shift is described with reference to Figs. 4 to 7.

Fig. 4 shows a side view of the small-diameter substrate shift mechanism, Fig. 5 shows a cross section view taken along V-V line of a head portion in Fig. 4, Fig. 6 shows a cross section view taken along VI-VI line of the head portion in Fig. 4, and Fig. 7 shows a cross section view taken along VII-VII line of the head portion in Fig. 4.

In Fig. 4, a numeral 16 denotes a drive shaft of a motor. Cams 21, 22 and 23 are provided in the head portion 20 while being fixed to the drive shaft 16.

In Fig. 5, a roller 52 is provided in a lower portion of a cam follower 51, and a spring 53 is provided in an upper

portion thereof. The spring 53 biases the cam follower 51 to a lower side in the figure. When the cam 21 makes one revolution clockwise, vertical reciprocating operation of the cam follower 51 is performed one time. The cam follower 51 has four lift members 24. The lift members 24 are set to be situated below the movable claw 11 for holding the small-diameter sputter carrier substrate with the small-diameter substrate shift mechanism being opposed to the 3.5 in. sputter holder 13. Therefore, the lift members 24 vertically move the movable claw 11 for holding the small-diameter sputter carrier substrate in accordance with one revolution of the cam 21.

In Fig. 6, a roller 62 is provided in a lower portion of a cam follower 61, and a spring 63 is provided in an upper portion thereof. The spring 63 is operated to bias the roller 62 to the left in the figure. A disk 65 is connected to the cam follower 61 via a shaft 64. Four cylindrical portions 66 are engaged with the periphery of the disk 65 by gears. A pair of swinging members as described later are provided within each of the cylindrical portions 66. When the cam 22 makes one revolution clockwise, the cam follower 61 performs operation one time, the operation being operation that a roller attachment portion is reciprocated left and right to rotate the shaft 64 counterclockwise and then rotate it clockwise. Therefore, the disk 65 rotates the four cylindrical portions

66 clockwise by a predetermined angle, then reversely rotates them, and then returns to an original position.

In Fig. 7, a roller 72 is provided in a lower portion of a cam follower 71, and a spring 73 is provided in an upper portion thereof. The spring 73 biases the cam follower 71 to a lower side in the figure. When the cam 23 makes one revolution clockwise, vertical reciprocating operation of the cam follower 71 is performed one time. The cam follower 71 has convex portions 74 at four 4 places correspondingly to the substrates. A right end of a swinging member 76 is situated on an upper part of each of the convex portions 74. The swinging member 76 is pivoted by a shaft 78, and biased to a lower side by a spring 75 at a right end. A swinging member 77 pivoted by a shaft 79 is provided facing the swinging member 76 in a middle portion between a left end of the swinging member 76 and the shaft 78. A right end of the swinging member 77 is connected to the middle portion by a tension spring (not shown).

Therefore, the convex portions 74 swing the swinging members 76 with vertical movement of the cam follower 71, and the swinging members 77 swing by being driven by this. Swinging directions of the members 76 and 77 are opposite to each other. Accordingly, two left ends of the swinging members 76 and 77, which are opposed to each other, approach each other and

separate from each other with rotation of the cam 23. At that time, central positions of the left ends of them are vertically moved, and the central positions are offset much to an upper side in the case that the swinging members 76 and 77 separate from each other compared with the case that the swinging members 76 and 77 approach each other. The swinging members 76 and 77 are disposed such that the left ends of them are inserted into central holes of the substrates, and grooves 80 support internal edges of the substrates.

Furthermore, the swinging members 76 and 77 are configured to integrally rotate with rotation of the cylindrical portions 66 in accordance with rotation of the cam 22.

Next, substrate shift operation by the small-diameter substrate shift mechanism having the above configuration is described with reference to a cam chart of Fig. 8 and an operation state diagram of Fig. 9. Positions of the cams as shown in Figs. 5 to 7 show positions at a rotation phase of 45° in Fig. 8. Hereinafter, "chuck" means an opening/closing holding mechanism of a substrate including the pair of swinging members.

When the cam 21 takes one revolution in Fig. 8, the spring

member of each of the movable claws 11 for holding the small-diameter sputter carrier substrates is moved up and opened from a position of supporting an upper end of the small-diameter chemical-tempered glass substrate 9 in a closed condition by displacement of the cam in the phase 4. Therefore, pressing force to the small-diameter chemical-tempered glass substrate 9 by elastic force of the spring member is blocked. Displacement of the cam in the phase 8 is in an opposite direction to that in the phase 4, by which the spring member is moved down, and returned to the position of supporting the upper end of the small-diameter chemical-tempered glass substrate 9 from the position of blocking the pressing force to the small-diameter chemical-tempered glass substrate 9 in an opened condition.

When the cam 23 takes one revolution, each chuck including the swinging members 76 and 77 is opened from a condition of releasing the small-diameter chemical-tempered glass substrate 9 from a center hole side in a closed condition by displacement of the cam in the phase 2, so that the small-diameter chemical-tempered glass substrate 9 is held. Displacement of the cam in the phase 10 is in an opposite direction to that in the phase 2, by which the chuck is closed so that the small-diameter chemical-tempered glass substrate 9 is released again.

When the cam 22 takes one revolution, a rotation position of each cylindrical portion 66 in the phase 6 is displaced to a position rotated by a predetermined angle from an initial position. The chuck is also rotated by a predetermined angle in accordance with this. Displacement of the cam in the phase 12 is in an opposite direction to that in the phase 6, by which the cylindrical portion 66 is returned to the initial position, and the chuck is also returned to an original rotation position.

Operation conditions of the spring member, chuck, and cylindrical portions 66 due to the one revolution of the three cams are as shown in Fig. 9. As a result, each small-diameter chemical-tempered glass substrate 9, which is supported at the upper end and released at a center hole side in the initial position, is first fixed at the center hole side, then freely released at the upper end, and then rotated at the predetermined angle, and then supported at the upper end, and then released at the center hole side. Since the chuck is offset to the upper side when the small-diameter chemical-tempered glass substrate 9 is fixed at the center hole side, the substrate is raised such that the lower end of the small-diameter chemical-tempered glass substrate 9 is separated from the stationary claws 12 for holding the small-diameter sputter carrier substrate. Thus, each small-diameter chemical-tempered glass substrate 9 is shifted and supported

such that the movable claw 11 for holding the small-diameter sputter carrier substrate, which has held the insulating portion being not subjected to deposition, holds the seed layer 2 being the deposited conductive layer. Then, the rotation position of the chuck (cylindrical portion 66) is returned to the initial position.

Once the small-diameter chemical-tempered glass substrate 9 is shifted to achieve electrical conduction after depositing the seed layer as described above, the nonmagnetic orientation control layer 3, nonmagnetic base layer 4, nonmagnetic intermediate layer 5, magnetic layer 6, passivation film 7, and liquid lubricant layer 8 are successively deposited with the bias voltage being applied in the sputter apparatus.

As hereinbefore, according to an embodiment of the invention, even if multiple-substrate-processing is performed for improving productivity, since upper layers with respect to the seed layer can be deposited with the bias voltage being applied, a magnetic recording medium without inducing reduction in property or deterioration in quality can be manufactured, consequently improvement in productivity can be realized while high quality is kept. Moreover, since the small-diameter sputter carrier can be easily replaced with a

usual one, a usual substrate and a small-diameter substrate can be successively subjected to deposition.

What is claimed is:

1. Manufacturing apparatus of a magnetic recording medium, comprising:

in deposition apparatus for stacking a plurality of layers including a magnetic layer on each of the plurality of insulating substrates,

a carrier of holding a plurality of insulating substrates, the carrier having a plurality of support members for supporting respective predetermined positions on the plurality of insulating substrates, and

a shift mechanism of collectively changing positions on the plurality of insulating substrates supported by the plurality of support members to different positions by rotating the plurality of insulating substrates held by the carrier by a predetermined rotation angle,

wherein the plurality of support members are electrically conductive, and electrically connected to a bias unit for applying a bias voltage on the plurality of insulating substrates.

2. The manufacturing apparatus according to claim 1:

wherein the plurality of insulating substrates have a disk-like shape and center holes respectively,

the plurality of support members have deformation portions to be elastically deformed and contact portions being set at one ends of the deformation portions for contacting to

end faces of the insulating substrates,

the shift mechanism has,

a plurality of first members of performing closing operation for holding the substrates from a side of the center holes of the plurality of insulating substrates, opening operation for releasing the substrates, and rotation operation in a direction parallel to surfaces of the substrates, and

a plurality of second members of performing supporting operation of supporting the insulating substrates by contacting the contacting portions to the end faces to transmit elastic force of deformation portions to the insulating substrates, and blocking operation of blocking elastic force of the deformation portions to the insulating substrates by separating the contact portions from the end faces, the second members being provided correspondingly to the plurality of insulating substrates, the first and second members being provided correspondingly to the plurality of insulating substrates, and

a plurality of cams provided on one rotational shaft, and a transmission mechanism of transmitting rotation of the cams to the plurality of first members and the plurality of second members, and

the cams and the transmission mechanism are configured to allow the closing operation, the blocking operation, the rotation operation by the predetermined rotation angle, and

the supporting operation to be performed successively in accordance with rotation of the shaft.

3. The manufacturing apparatus according to claim 2:

wherein the apparatus is configured such that each of the plurality of first members has a first swinging member swinging with a predetermined swinging center as a center while being reciprocally biased at one end by the transmission mechanism, and a second swinging member of which one end is disposed facing a middle portion between the other end of the first swinging member and the swinging center, and the other end is disposed facing the other end of the first swinging member, the one end of the second member is connected to the middle portion by a tension spring, and both the other ends are inserted into the center hole, and

the second swinging member swings via the tension spring in accordance with swinging of the first swinging member, thereby the described, both the other ends approach each other to perform the opening operation, and the described, both the other ends are separated from each other to perform the closing operation, and as an interval between the described, both the other ends is changed, a middle position of the interval is offset, thereby the insulating substrates are displaced to be separated from the carrier in the closing operation.

4. The manufacturing apparatus according to claims 1 to 3, further comprising:

a mechanism of attaching or removing the carrier, which attaches or removes a different carrier for holding a different insulating substrate being large compared with the insulating substrates.

5. A method of manufacturing a magnetic recording medium, comprising:

a first step of supporting respective predetermined positions of the plurality of insulating substrates by a plurality of conductive support members to hold the substrates,

a second step of depositing conductive layers on the held, plurality of insulating substrates respectively,

a third step of rotating the plurality of insulating substrates, thereby collectively changing the positions on the plurality of insulating substrates supported by the plurality of support members from the predetermined positions to different positions at which the conductive layers were deposited, and

a fourth step of stacking a plurality of layers including a magnetic layer on the conductive layer on each of the plurality of insulating substrates while a bias voltage is applied on the plurality of insulating substrates through the plurality of support members and the conductive layers.