

DESCRIPTION

Title of Invention

FILM-FORMING APPARATUS, CARRIER AND METHOD OF
MANUFACTURING SUBSTRATE ON WHICH FILM IS FORMED

5

Technical Field

[0001]

The present invention relates to a film-forming apparatus, a carrier and a method of manufacturing a substrate on which a film is formed.

10 Background Art

[0002]

A magnetic recording medium used in a hard disk device or the like has, for example, a structure in which a seed film, a base film, a magnetic recording film, a protective film, and a lubricant film are sequentially formed on one or both surfaces of a non-magnetic substrate, and in general, such a magnetic recording medium is manufactured by an in-line film-forming apparatus that performs a film-forming process while transporting a carrier that holds a substrate (for example, Patent Document 1 and Patent Document 2).

20 [0003]

An in-line film-forming apparatus disclosed in Patent Document 1 has a structure in which plural chambers that perform film-forming processes are connected via gate valves. In each chamber, plural rotation bodies rotating around a horizontal axis are provided in line in a transport direction of a carrier, and the carrier is guided by the plural rotation bodies. In addition, in each chamber, plural rotation bodies rotating around a vertical axis are provided in line in the transport direction of the carrier, and

the carrier is also guided by the plural rotation bodies.

[0004]

On the other hand, the carrier includes plural holders, each provided with a hole portion for arranging a substrate inside thereof and plural clamping clips that are elastically deformable and attached around the hole portion. The holder detachably holds the substrate fitted inside the clamping clips.

[0005]

Also in an in-line film-forming apparatus disclosed in Patent Document 2, a structure in which plural chambers performing film-forming processes are connected via gates is provided. Also in this film-forming apparatus, the film-forming processes are performed while transporting a carrier that holds a substrate. In the film-forming apparatus, carrier is transported while pressing a side surface of the carrier against a side surface of a rail by use of a magnetic force or the like. Accordingly, the carrier is transported while vibrations thereof are suppressed.

Citation List

Patent Literature

[0006]

Patent Document 1: Japanese Patent Application Laid-Open Publication No. 8-274142

Patent Document 2: U.S. Patent No. 8382965

Summary of Invention

Technical Problem

[0007]

Incidentally, as described above, in the case where the carrier is guided by use of the rotation body, the vibrations of the carrier are apt to occur. In a configuration provided with the rotation body, the rotation body and the carrier collide with each other every time the carrier reaches the rotation body, and thereby the carrier vibrates. If the carrier vibrates in this way, the substrate held by the carrier is apt to drop off. In addition, the vibrations of the carrier cause friction between the carrier and the peripheral components, and wear particles are generated due to the friction. Then, the wear particles leads to deterioration of product quality.

[0008]

On the other hand, as described above, in a configuration in which the carrier is transported while pressing the side surface of the carrier against the side surface of the rail by use of a magnetic force or the like, the vibrations of the carrier are suppressed compared to the above-described configuration using the rotation body. However, in the case where the carrier is pressed against the rail by use of a magnetic force or the like, the structure becomes complicated. Moreover, in this case, there is a possibility that transportation of the carrier becomes unstable such that the carrier is hard to be transported at a position where magnetic field strength is high, whereas the carrier is easily moved at a position where magnetic field strength is low.

[0009]

An object of the present invention is suggested in light of the conventional circumstances, and is to suppress the vibrations of the carrier caused when the carrier is transported, to thereby transport the carrier stably.

Solution to Problem

[0010]

A film-forming apparatus to which the present invention is applied includes: a guiding mechanism that guides a carrier transported along a transporting route while holding a substrate on which a film-forming process is performed, wherein the guiding mechanism includes: a first support surface that is arranged on one lateral side of the transporting route and supports a part of the carrier transported on the transporting route from beneath; and a second support surface that is arranged on an opposite side of the first support surface across the transporting route and supports a part of the carrier transported on the transporting route from beneath, and wherein the first support surface is provided with a tilt descending toward a side where the second support surface is provided, and the second support surface is provided with a tilt descending toward a side where the first support surface is provided.

Here, the first support surface is arranged on the one lateral side of the transporting route and is arranged along the transporting route to support the part of the carrier transported on the transporting route from beneath and to guide the part, and the second support surface is arranged on the other lateral side of the transporting route and is arranged along the transporting route to support the part of the carrier transported on the transporting route from beneath and to guide the part.

Moreover, each of a portion of the carrier to be supported by the first support surface and a portion of the carrier to be supported by the second support surface is provided with a rotating member. In this case, it becomes possible to transport the carrier smoothly.

Moreover, the portion to be supported by the first support surface is

provided with a first rotating member that rotates around a rotational shaft having one end and the other end, and the portion to be supported by the second support surface is provided with a second rotating member that rotates around a rotational shaft having one end and the other end, the first
5 rotating member is arranged so that the one end of the rotational shaft is positioned at the transporting route side and the other end of the rotational shaft is positioned at the one lateral side, and the other end is positioned above the one end to incline the rotational shaft with respect to a horizontal direction, and the second rotating member is arranged so that the one end of
10 the rotational shaft is positioned at the transporting route side and the other end of the rotational shaft is positioned at the other lateral side, and the other end is positioned above the one end to incline the rotational shaft with respect to the horizontal direction. In this case, it becomes easy to arrange the outer circumferential surface of the first rotating member along the first
15 support surface, and to arrange the outer circumferential surface of the second rotating member along the second support surface, and accordingly, it becomes possible to support the first rotating member by the first support surface and to support the second rotating member by the second support surface more stably.

20 Moreover, each of the first rotating member and the second rotating member includes a hollow-cylindrical rotating body, the first support surface contacts an outer circumferential surface of the rotating body of the first rotating member from beneath to support the first rotating member, and the second support surface contacts an outer circumferential surface of the
25 rotating body of the second rotating member from beneath to support the second rotating member. In this case, it is possible to reduce wear particles generated due to friction between the first support surface and the first

rotating member and wear particles generated due to friction between the second support surface and the second rotating member.

Moreover, of the carrier, the portion to be supported by the first support surface and the portion to be supported by the second support surface are located above a center of gravity of the carrier. In this case, it becomes possible to reduce vibrations of an upper portion of the carrier.

[0011]

In a case where the present invention is grasped as a carrier, a carrier to which the present invention is applied is a carrier, to which a substrate to be subjected to a film-forming process is attached, transported along a transporting route provided in a film-forming apparatus while being guided by a guiding portion provided on one lateral side of the transporting route and a guiding portion provided on the other lateral side of the transporting route, and the carrier includes: a carrier main body, to which the substrate is attached, that is transported on the transporting route in the film-forming apparatus; a first rotating member that is provided rotatably around a rotational shaft having one end and the other end, and is guided by the guiding portion provided at the one lateral side while being supported from beneath when the carrier main body is transported on the transporting route; and a second rotating member that is provided rotatably around a rotational shaft having one end and the other end, and is guided by the guiding portion provided at the other lateral side while being supported from beneath when the carrier main body is transported on the transporting route, wherein, the first rotating member is arranged so that, when the carrier main body is transported on the transporting route, the one end of the rotational shaft is positioned at the transporting route side and the other end is positioned at the one lateral side, and the other end is

positioned above the one end to incline the rotational shaft with respect to a horizontal direction, and the second rotating member is arranged so that, when the carrier main body is transported on the transporting route, the one end of the rotational shaft is positioned at the transporting route side and the other end is positioned at the other lateral side, and the other end is positioned above the one end to incline the rotational shaft with respect to the horizontal direction.

Here, the first rotating member and the second rotating member are provided so that setting positions of the first rotating member and the second rotating member are different from each other in a transporting direction when the carrier main body is transported on the transporting route. In this case, compared to a case where the setting positions of the first rotating member and the second rotating member are same in the transporting direction when the carrier main body is transported on the transporting route, it is possible to reduce a thickness of the carrier in a direction orthogonal to the transporting direction.

[0012]

In a case where the present invention is grasped as a method of manufacturing a substrate on which a film is formed, a method of manufacturing a substrate on which a film is formed, to which the present invention is applied, is a method in which a carrier holding a substrate is transported and a film-forming process is performed on the substrate to manufacture a film-forming substrate that is a substrate to be subjected to the film-forming process, and the method includes: when the carrier is transported, guiding the carrier by a guiding mechanism that guides the carrier to transport the carrier along a predetermined transporting route, wherein the guiding mechanism includes: a first support surface that is

arranged on one lateral side of the transporting route and supports a part of the carrier transported on the transporting route from beneath; and a second support surface that is arranged on an opposite side of the first support surface across the transporting route and supports a part of the carrier transported on the transporting route from beneath, and wherein the first support surface is provided with a tilt descending toward a side where the second support surface is provided, and the second support surface is provided with a tilt descending toward a side where the first support surface is provided.

Advantageous Effects of Invention

[0013]

According to the present invention, it is possible to suppress the vibrations of the carrier caused when the carrier is transported, while transporting the carrier stably.

Brief Description of Drawings

[0014]

FIG. 1 is a cross-sectional view of a magnetic recording medium manufactured by a magnetic recording medium manufacturing apparatus;

FIG. 2 is a diagram for illustrating the manufacturing apparatus;

FIG. 3 is a perspective view of a carrier;

FIG. 4 is a diagram showing an upper roll pair located at a rightmost position in FIG.3 as viewed from a direction of arrow IV in FIG. 3;

FIG. 5 is a diagram for illustrating a carrier guide shown in FIG. 2;

FIG. 6 is a diagram showing a carrier transporting roll as viewed from a lateral side;

FIG. 7 is a diagram showing the carrier guided by an upper carrier guide and a lower carrier guide as viewed from an upstream side in a transporting direction of the carrier;

FIG. 8 is a diagram showing a comparative example of the carrier
5 and the carrier guide;

FIG. 9 is a diagram showing the comparative example of the carrier and the carrier guide; and

FIG. 10 is a diagram showing vibrations of the carrier in the exemplary embodiment and vibrations of the carrier in the comparative
10 example.

Description of Embodiments

[0015]

Hereinafter, an exemplary embodiment according to the present
15 invention will be described with reference to attached drawings.

FIG. 1 is a cross-sectional view of a magnetic recording medium manufactured by a magnetic recording medium manufacturing apparatus (hereinafter, referred to as “manufacturing apparatus”) according to the present invention.

20 A magnetic recording medium 100 (hereinafter, referred to as “recording medium 100”) shown in FIG. 1 is a disc-shaped recording medium 100 used in a hard disk device or the like. The recording medium 100 is provided with a substrate (a non-magnetic substrate) 80.

[0016]

25 Further, on one or both surfaces of the substrate 80, a seed layer 81, a base film 82, a magnetic recording film 83, a protective film 84 and a lubricant layer 85 are formed in order toward a surface of the recording

medium 100. The recording medium 100 is manufactured by an in-line manufacturing apparatus (film-forming apparatus) 200 shown in FIG. 2 (a diagram for illustrating the manufacturing apparatus).

[0017]

5 The manufacturing apparatus 200 shown in FIG. 2 is provided with plural carriers 25 that is circularly transported in the clockwise direction in the figure while holding the substrates 80. The manufacturing apparatus 200 is also provided with: a robot stage 1; a substrate moving robot 3; a substrate supply robot chamber 2; a substrate supply robot 34; a substrate
10 mounting chamber 52; corner chambers 4, 7, 14 and 17 for rotating the carriers 25; sputtering film-forming chambers 5, 6, 8-13, 15 and 16 that form films on the substrates 80 by sputtering; protective film forming chambers 18-20 that form the protective films; a substrate dismounting chamber 54; a substrate dismounting robot chamber 22; a substrate
15 dismounting robot 49; and an ashing chamber 3A for the carriers 25.

[0018]

A not-shown vacuum pump is connected to each of the substrate supply robot chamber 2, the substrate mounting chamber 52, the corner chambers 4, 7, 14 and 17, the sputtering film-forming chambers 5, 6, 8-13,
20 15 and 16, the protective film forming chambers 18-20, the substrate dismounting chamber 54 and the ashing chamber 3A, and each of these chambers is brought into a pressure reduction state by the vacuum pump.

[0019]

Moreover, each chamber is provided with a carrier guide 210 that
25 guides the transported carrier 25. It should be noted that, in FIG. 2, the carrier guide 210 is shown only in the sputtering film-forming chamber 8 to make the figure more visible. In the exemplary embodiment, the carrier 25

that holds the substrate 80 moves in each chamber having been brought into the pressure reduction state while being guided by the carrier guide 210. Further, by passing through each chamber, the seed layer 81, the base film 82, the magnetic recording film 83, the protective film 84 and the like described with reference to FIG. 1 are formed on the surface of the substrate 80.

[0020]

FIG. 3 is a perspective view of the carrier 25.

It should be noted that, in this specification, the direction indicated by arrow 3A in FIG. 3 is referred to as a width direction of the carrier 25, the direction indicated by arrow 3B in FIG. 3 is referred to as a height direction of the carrier 25, and the direction indicated by arrow 3C in FIG. 3 is referred to as a depth direction of the carrier 25 in some cases.

[0021]

As shown in FIG. 3, the carrier 25 is provided with a plate-like carrier main body 250. In a lower portion of the carrier main body 250, a support plate 26 is provided. Further, in an upper portion of the carrier main body 250, a substrate mounting portion 27, on which the substrate 80 is mounted, is provided. It should be noted that, in the exemplary embodiment, two substrate mounting portions 27 are provided, and accordingly, the carrier 25 is configured to be capable of mounting two substrates 80 (not shown in FIG. 3).

[0022]

The support plate 26 is provided with a lower guided portion 28 that is to be guided by the carrier guide 210 (refer to FIG. 2) provided in each chamber. Moreover, above the lower guided portion 28, an upper guided portion 29 to be similarly guided by the carrier guide 210 provided in each

chamber is provided.

[0023]

Here, the upper guided portion 29 is provided with five pairs of rolls 91 (hereinafter, referred to as “upper roll pairs 91”) in total, each of which is configured with two roll-like members. Here, the upper roll pairs 91 are arranged in line along the width direction of the carrier 25. To additionally describe, in the exemplary embodiment, the carrier 25 is transported in the direction indicated by arrow 3X in the figure, and each of the upper roll pairs 91 is arranged along the transporting direction of the carrier 25.

[0024]

The lower guided portion 28 is also provided with pairs of rolls 92 (hereinafter, referred to as “lower roll pairs 92”), each of which is configured with two roll-like members. Here, the lower guided portion 28 is provided with four lower roll pairs 92 in total. Similar to the upper roll pairs 91, these four lower roll pairs 92 are arranged in line along the width direction of the carrier 25. To additionally describe, the lower roll pairs 92 are arranged along the transporting direction of the carrier 25.

[0025]

FIG. 4 is a diagram showing an upper roll pair 91 located at a rightmost position in FIG.3 as viewed from a direction of arrow IV in FIG. 3.

As shown in the figure, the upper roll pair 91 is provided with a first roll-like member 911 as an example of a first rotating member and a second roll-like member 912 as an example of a second rotating member. Here, the first roll-like member 911 and the second roll-like member 912 are arranged at positions different from one another in the width direction of the carrier 25.

To additionally describe, the first roll-like member 911 and the

second roll-like member 912 are arranged at different positions from one another in the transporting direction of the carrier 25, that is, the first roll-like member 911 is positioned on an upstream side in the transporting direction of the carrier 25, whereas the second roll-like member 912 is positioned on a downstream side in the transporting direction of the carrier 25.

[0026]

The first roll-like member 911 is provided with a disc-shaped (hollow-cylindrical) rotating body 911A. A rotational shaft 911B passes through the rotating body 911A, and the rotating body 911A rotates around the rotational shaft 911B. Here, in the exemplary embodiment, the rotational shaft 911B is arranged in a state of being inclined 45° with respect to the vertical direction (the top-to-bottom direction in the figure). To additionally describe, the rotational shaft 911B has one end 911D and the other end 911E, and the rotational shaft 911B is arranged in the inclined state so that the other end 911E is positioned above the one end 911D.

[0027]

To describe further, in the exemplary embodiment, the carrier 25 is transported along a plane including a straight line SL indicated by a chain double-dashed line in FIG. 4, which is also a plane orthogonal to the page of FIG. 4 (the portion where the orthogonal plane passes becomes a transporting route of the carrier 25, and the carrier 25 is transported on the transporting route); however, in the exemplary embodiment, the one end 911D is positioned at the straight line SL side and the other end 911E is positioned at a side opposite to the side where the straight line SL is provided. To additionally describe, the other end 911E is positioned at one lateral side of the transporting route of the carrier 25. Further, in the

exemplary embodiment, the other end 911E is positioned above the one end 911D.

[0028]

Moreover, the same is true for the second roll-like member 912 side,
5 and the second roll-like member 912 is provided with a disc-shaped
(hollow-cylindrical) rotating body 912A and a rotational shaft 912B passing
through the rotating body 912A. Then, similar to the first roll-like member
911 side, the rotational shaft 912B is arranged in a state of being inclined
45° with respect to the vertical direction (the top-to-bottom direction in the
10 figure).

[0029]

To describe further, the second roll-like member 912 is also in the
state where the rotational shaft 912B is inclined so that the other end 912G
is positioned above one end 912F. To describe furthermore, similar to the
15 first roll-like member 911 side, the one end 912F of the rotational shaft
912B is positioned at the straight line SL side, whereas the other end 912G
is positioned at the opposite side of the straight line SL. To additionally
describe, the other end 912G is positioned at the other lateral side of the
transporting route of the carrier 25. Further, the other end 912G is
20 positioned above the one end 912F.

[0030]

It should be noted that, in the exemplary embodiment, there is a
difference between the direction in which the rotational shaft 911B of the
first roll-like member 911 is inclined and the direction in which the
25 rotational shaft 912B of the second roll-like member 912 is inclined; the
rotational shaft 911B of the first roll-like member 911 is inclined toward one
surface side of the carrier 25 (on the one lateral side of the transporting

route of the carrier 25) and the rotational shaft 912B of the second roll-like member 912 is inclined toward the other surface side of the carrier 25 (on the other lateral side of the transporting route of the carrier 25).

[0031]

5 FIG. 5 is a diagram for illustrating the carrier guide 210 shown in FIG. 2. It should be noted that FIG. 5 shows the carrier guide 210 in a state as viewed from the direction of arrow V in FIG. 2. To additionally describe, FIG. 5 shows the carrier guide 210 in a state as viewed from an upstream side in the transporting direction of the carrier 25.

10 [0032]

As shown in FIG. 5, the carrier guide 210 is configured with an upper carrier guide 210U that guides the upper guided portion 29 shown in FIG. 3 and a lower carrier guide 210L that guides the lower guided portion 28 shown in FIG. 3.

15 [0033]

Here, the upper carrier guide 210U and the lower carrier guide 210L are arranged along the transporting direction of the carrier 25. Moreover, the upper carrier guide 210U and the lower carrier guide 210L are provided in each of the above-described chambers provided in the manufacturing apparatus 200, and in each chamber, provided to bridge an entrance and an exit of the chamber.

20 [0034]

The upper carrier guide 210U as an example of a guiding mechanism is configured with a first rod-like member 310 and a second rod-like member 320 that have a rectangular cross-sectional shape. Here, in the exemplary embodiment, the first rod-like member 310 and the second rod-like member 320 are arranged in a state with a gap K1 being formed

therebetween. In the exemplary embodiment, the carrier 25 passes through the gap K1. To additionally describe, the exemplary embodiment has a configuration in which the transporting route of the carrier 25 is provided between the first rod-like member 310 and the second rod-like member 320 that function as a guiding portion.

[0035]

To describe further, the first rod-like member 310 is arranged on one lateral side of the transporting route and along the transporting route, to thereby support part of the carrier 25 that is transported on the transporting route and to guide the part. Moreover, the second rod-like member 320 is arranged on the other lateral side of the transporting route and along the transporting route, to thereby support the other part of the carrier 25 that is transported on the transporting route and to guide the other part.

[0036]

Further, each of the first rod-like member 310 and the second rod-like member 320 are arranged in an inclined state in which one side positioned in the gap K1 is located above the other side opposite to the one side positioned in the gap K1. It should be noted that, in the exemplary embodiment, the inclination angle is 45° with respect to the horizontal direction.

[0037]

It should be noted that, in the exemplary embodiment, a first block body BK1 and a second block body BK2 formed in a V-shape with a groove having an opening angle of 90° being formed are provided. Then, in the exemplary embodiment, the first rod-like member 310 is placed in the groove formed in the first block body BK1 and the second rod-like member 320 is placed in the groove formed in the second block body BK2. Further, the

first rod-like member 310 is fastened to the first block body BK1 with bolts BL and the second rod-like member 320 is also fastened to the second block body BK2 with the bolts BL.

[0038]

5 Next, the lower carrier guide 210L will be described.

 The lower carrier guide 210L is also provided with a first rod-like member 410 and a second rod-like member 420 that have a rectangular cross-sectional shape. Here, in the lower carrier guide 210L, a gap K2 is also formed between the first rod-like member 410 and the second rod-like member 420. It should be noted that each of the first rod-like member 410 and the second rod-like member 420 is not inclined like the first rod-like member 310 and the second rod-like member 320, but is arranged in a state of lying in the horizontal direction.

[0039]

15 A structure of the manufacturing apparatus 200 will be further described with reference to FIG. 5.

 In the exemplary embodiment, below the lower carrier guide 210L (below the gap K2 formed between the first rod-like member 410 and the second rod-like member 420), a carrier transporting roll 500 that transports the carrier 25 using magnetism is provided.

[0040]

 FIG. 6 is a diagram showing the carrier transporting roll 500 as viewed from a lateral side. It should be noted that the figure also shows the carrier 25.

25 The carrier transporting roll 500 is a cylindrical or hollow-cylindrical member, and as shown in the figure, magnetic poles 51 and 52 arranged in a helical fashion are formed on a circumferential surface thereof.

[0041]

The magnetic poles 51 and 52 are configured by partitioning helical parts formed on the circumferential surface of the carrier transporting roll 500 into smaller parts and magnetizing each of the parts. Moreover, in the exemplary embodiment, as shown in FIG. 6, the two helical magnetic poles 51 and 52 are arranged in front-to-back displacement. Of the two magnetic poles 51 and 52, the magnetic pole 51 forms an S-pole, and the magnetic pole 52 forms an N-pole.

[0042]

On the other hand, though illustration and description have been omitted above, magnets 35 are also provided in the carrier 25 side (hereinafter, referred to as "carrier-side magnet 35"). Here, the carrier-side magnets 35 are provided on a lower edge portion of the carrier 25. Moreover, the carrier-side magnet 35 is a small magnet of a rectangular-parallelepiped-shape, and the plural carrier-side magnets 35 are provided at predetermined intervals along the lower edge of the carrier 25.

[0043]

Moreover, the carrier-side magnet 35 is arranged so that the magnetic poles appear on the top and bottom surfaces thereof. Further, the carrier-side magnets 35 are arranged so that the magnetic poles on a side where the carrier transporting roll 500 is positioned appear alternately in an axial direction of the carrier transporting roll 500. Moreover, arrangement intervals of the carrier-side magnets 35 correspond to arrangement intervals of the two magnetic poles 51 and 52 provided on the carrier transporting roll 500 positioned below.

[0044]

In the exemplary embodiment, the carrier-side magnets 35 are

magnetically coupled to the magnetic poles 51 and 52 on the carrier transporting roll 500 below. Specifically, the carrier-side magnets 35 of the N-pole are coupled to the magnet poles 51 of the S-pole on the carrier transporting roll 500 and the carrier-side magnets 35 of the S-pole are coupled to the magnet poles 52 of the N-pole. Under this condition, when the carrier transporting roll 500 rotates, the carrier 25 is transported along the axial direction of the carrier transporting roll 500.

[0045]

FIG. 7 is a diagram showing the carrier 25 guided by the upper carrier guide 210U and the lower carrier guide 210L as viewed from the upstream side in the transporting direction of the carrier 25.

It should be noted that, in FIG. 7, of the five upper roll pairs 91 provided, one upper roll pair 91 is shown; however, the rest of four upper roll pairs 91 are also in the same state as shown in FIG. 7. Moreover, with respect to the lower roll pairs 92, of the four lower roll pairs 92 provided, one lower roll pair 92 is shown; however, the rest of three lower roll pairs 92 are also in the same state as shown in FIG. 7.

[0046]

As shown in FIG. 7, in the exemplary embodiment, the upper roll pair 91 is placed on the upper carrier guide 210U, and the carrier 25 is supported by the upper carrier guide 210U from beneath. Under the condition, the carrier 25 is transported toward the downstream side; however, at this time, the portion where the upper roll pair 91 is provided is guided by the upper carrier guide 210U. Here, at this time, two rotating bodies 911A and 912A provided to the upper roll pair 91 rotate, and accordingly, the carrier 25 is smoothly transported toward the downstream side.

[0047]

Further, the exemplary embodiment has a configuration in which the carrier 25 is pressed against the upper carrier guide 210U, and as a result of this, displacement of the carrier 25 in the height direction is hard to occur in the exemplary embodiment. To describe specifically, in the exemplary embodiment, gravity acts on the carrier 25. Moreover, by the magnetic force that interacts between the carrier transporting roll 500 (refer to FIG. 6) and the carrier 25, the carrier 25 is pulled downwardly. Consequently, the carrier 25 is pressed against the upper carrier guide 210U, to thereby cause the carrier 25 to be hard to be displaced in the height direction.

[0048]

Moreover, in the exemplary embodiment, as a result of pressing the carrier 25 against the upper carrier guide 210U, a load is imposed on the carrier 25 from beneath as indicated by arrow 7A in the figure.

Further, in the exemplary embodiment, since the first rod-like member 310 and the second rod-like member 320 provided to the upper carrier guide 210U are inclined 45° with respect to the horizontal direction as described above, a first horizontal-direction load 7B and a second horizontal-direction load 7C acting in the horizontal direction become imposed on the carrier 25 as shown in FIG. 7.

[0049]

To additionally describe, in the exemplary embodiment, of the first rod-like member 310, a support surface that supports the carrier 25 from beneath (a surface indicated by a reference sign 7X in the figure, hereinafter referred to as “first support surface 7X”) is inclined 45° with respect to the horizontal direction; therefore, the first horizontal-direction load 7B acting in

the horizontal direction has come to be imposed on the carrier 25.

Moreover, of the second rod-like member 320, a support surface that supports the carrier 25 from beneath (a surface indicated by a reference sign 7Y in the figure, hereinafter referred to as “second support surface 7Y”) is inclined 45° with respect to the horizontal direction; therefore, the second horizontal-direction load 7C acting in the horizontal direction has come to be imposed on the carrier 25.

[0050]

To describe further, in the exemplary embodiment, since the first support surface 7X is provided with a tilt descending toward a side where the second support surface 7Y is provided, and the second support surface 7Y is provided with a tilt descending toward a side where the first support surface 7X is provided, the first horizontal-direction load 7B and the second horizontal-direction load 7C come to be imposed.

[0051]

Then, in this case, the carrier 25 is pressed against the second rod-like member 320 by the first horizontal-direction load 7B and the carrier 25 is pressed against the first rod-like member 310 by the second horizontal-direction load 7C. Accordingly, displacement of the carrier 25 in the thickness direction thereof has also come to be suppressed. To additionally describe, transportation of the carrier 25 in a direction orthogonal to the transporting direction of the carrier 25 has come to be suppressed.

[0052]

Further, the exemplary embodiment has, as shown in FIG. 7, a configuration in which a center of gravity G of the carrier 25 is positioned below the upper roll pair 91 and the center of gravity G of the carrier 25 is

positioned below a supporting position of the carrier 25 by the upper carrier guide 210U.

In this case, in comparison with a case of configuration in which the center of gravity G of the carrier 25 is positioned above the supporting position of the carrier 25 by the upper carrier guide 210U, vibrations in an upper portion side of the carrier 25 can be suppressed. Then, in this case, vibrations in the substrate mounting portion 27 (refer to FIG. 3) can also be suppressed.

[0053]

Next, with reference to FIG. 7, the lower roll pair 92 and the lower carrier guide 210L will be described.

Here, though description has been omitted above, the lower roll pair 92 is also provided with a first rod-like member 921 and a second rod-like member 922 as shown in FIG. 7. Here, the first roll-like member 921 and the second roll-like member 922 are arranged at positions different from one another in the width direction of the carrier 25. To additionally describe, the first roll-like member 921 and the second roll-like member 922 are arranged at different positions from one another in the transporting direction of the carrier 25. To describe further, the first roll-like member 921 is positioned on an upstream side in the transporting direction of the carrier 25, whereas the second roll-like member 922 is positioned on a downstream side in the transporting direction of the carrier 25.

[0054]

Moreover, the first roll-like member 921 is configured with a disc-shaped (hollow-cylindrical) rotating body 921A and a rotational shaft 921B passing through the rotating body 921A. The second roll-like member 922 is also configured with a disc-shaped (hollow-cylindrical) rotating body

922A and a rotational shaft 922B passing through the rotating body 922A.

[0055]

Here, in the lower roll pair 92, different from the upper roll pair 91, the rotational shaft 921B and the rotational shaft 922B are arranged along the vertical direction (the top-to-bottom direction in the figure). Moreover, in the lower roll pair 92, the first rod-like member 921 is shifted to one side surface side of the carrier 25 (a right side surface side in the figure), whereas the second rod-like member 922 is shifted to the other side surface side of the carrier 25 (a left side surface side in the figure).

[0056]

The carrier 25 in the exemplary embodiment is guided not only at the portion where the upper roll pair 91 is provided, but also at the portion where the lower roll pair 92 is located. Here, guiding in the lower roll pair 92 is performed by the rotating body 921A of the first rod-like member 921 brought into contact with the first rod-like member 410 and the rotating body 922A of the second rod-like member 922 brought into contact with the second rod-like member 420. As a result, in the exemplary embodiment, displacement of the carrier 25 in the thickness direction is also suppressed below the position of providing the upper roll pair 91.

[0057]

FIGS. 8 and 9 are diagrams showing a comparative example of the carrier 25 and the carrier guide 210. It should be noted that FIG. 8 shows the carrier 25 and the carrier guide 210 in a state as viewed from an upstream side in the transporting direction of the carrier 25, and FIG. 9 shows the carrier 25 and the carrier guide 210 in a state as viewed from above.

[0058]

As shown in FIG. 8, in the comparative example, a concave portion 25A is formed on one side surface side of the carrier 25. Further, inside the concave portion 25A, a first rotating body 216 that supports the carrier 25 from beneath is provided. Here, of the carrier 25, a V-shaped groove 25C is formed at a portion supported by the first rotating body 216 (a portion indicated by a reference sign 25B, hereinafter referred to as “supported portion 25B”), and in the comparative example, an outer circumferential edge of the first rotating body 216 enters into the groove 25C.

[0059]

Moreover, in this comparative example, a second rotating body 217 is located on the one side surface side of the carrier 25 and a third rotating body 218 is located on the other side surface side of the carrier 25, and accordingly, transportation of the carrier 25 in the thickness direction of the carrier 25 is restricted by the second rotating body 217 and the third rotating body 218. It should be noted that, in the comparative example, as shown in FIG. 9, plural first rotating bodies 216, plural second rotating bodies 217 and plural third rotating bodies 218 are provided to be arranged along the transporting direction of the carrier 25.

[0060]

In the case of the configuration of the comparative example, collision of the end portion of the carrier 25 with the first rotating body 216, the second rotating body 217 or the third rotating body 218 occurs, and therefore, vibrations of the carrier 25 become large compared to the configuration of the exemplary embodiment. Here, if the vibrations of the carrier 25 are large, there occurs a possibility that the substrate 80 drops off. Moreover, in the case where the carrier 25 collides with the first rotating body 216, the second rotating body 217 or the third rotating body 218, the

carrier 25 rubs against the first rotating body 216, the second rotating body 217 or the third rotating body 218, and accordingly, a lot of wear particles are generated. Then, if the wear particles are generated a lot in this way, the wear particles are apt to be included in the recording medium 100 to be manufactured, to thereby cause deterioration of product quality.

[0061]

On the other hand, in the configuration of the exemplary embodiment, the first rod-like member 310 and the second rod-like member 320 are formed in a longitudinal shape, and the carrier 25 is always pressed against the first rod-like member 310 and the second rod-like member 320. To additionally describe, the configuration maintains the contact between the carrier 25 and the carrier guide 210 while the carrier 25 is transported.

In such a case, collision as described above can be avoided, and the vibrations of the carrier 25 can be suppressed compared to the above-described comparative example. Moreover, in comparison with the above-described comparative example, generation of the wear particles can be suppressed.

[0062]

It should be noted that, between the first rod-like member 410, the second rod-like member 420 and the carrier 25 (the lower roll pair 92 thereof), there is a possibility that contact and separation between the first rod-like member 410, the second rod-like member 420 and the carrier 25 are repeated; however, in this case, the lower roll pairs 92 only contact the first rod-like member 410 and the second rod-like member 420 positioned at the lateral side in the proceeding direction of the lower roll pairs 92, and in this case, collision as described above does not occur.

To additionally describe, in the exemplary embodiment, the lower

roll pairs 92 do not contact some members positioned forward in the proceeding direction of the lower roll pairs 92, but contact some members positioned lateral side in the proceeding direction of the lower roll pairs 92 (the first rod-like member 410 and the second rod-like member 420), and therefore, collision as described above does not occur.

[0063]

However, even in the configuration of the exemplary embodiment, when the carrier 25 is transported to a different chamber (an adjacent chamber), the carrier 25 (the upper roll pairs 91 or the lower roll pairs 92 thereof) collides with an end portion of the first rod-like member 310, the second rod-like member 320, the first rod-like member 410 or the second rod-like member 420 provided in the different chamber, and accordingly, there occurs concerns about vibrations of the carrier 25 or generation of the wear particles.

[0064]

However, with the configuration of the exemplary embodiment, vibrations of the carrier 25 or generation of wear particles become suppressed in this case also.

In the configuration of the exemplary embodiment, on the carrier guide 210 side, only four members, namely, the first rod-like member 310, the second rod-like member 320, the first rod-like member 410 and the second rod-like member 420 are provided, that is, the number of components constituting the carrier guide 210 is small.

[0065]

In such a case, by maintaining positional accuracy of the four members, namely, the first rod-like member 310, the second rod-like member 320, the first rod-like member 410 and the second rod-like member

420, it becomes possible to suppress collision of the carrier 25 with these four members. Then, in this case, vibrations of the carrier 25 or generation of the wear particles can be suppressed.

On the other hand, in the configuration of the comparative example, a large number of first rotating bodies 216, second rotating bodies 217 and third rotating bodies 218 are provided, and therefore, it is difficult to maintain positional accuracy of all the rotating bodies, and it is difficult to avoid collision of the carrier 25 with the rotating bodies.

[0066]

Moreover, in the configuration of the exemplary embodiment, when the carrier 25 is transported to a different chamber (an adjacent chamber), in a state where rotation of the rotating bodies 911A, 912A, 921A and 922A provided in the upper roll pair 91 and the lower roll pair 92 attached to the carrier 25 is maintained, the rotating bodies 911A, 912A, 921A and 922A are brought into contact with the above-described four rod-like members located in the different chamber. In the case of such a configuration, generation of the wear particles has come to be suppressed.

In the above-described comparative example, since the carrier 25 contacts the rotating bodies 216, 217 and 218 that are stopped, a relative velocity difference between both of the carrier 25 and the rotating bodies 216, 217 and 218 becomes large, to thereby make more wear particles to be generated. In the configuration of the exemplary embodiment, the relative velocity difference becomes small, and therefore generation of the wear particles can be suppressed.

[0067]

Moreover, in the comparative example, as shown in FIG. 8, the supported portion 25B that is supported by the first rotating body 216 does

not exist on a center line CL of the carrier 25 (a vertical line that passes through the center of gravity (not shown) of the carrier 25), but is provided at a position displaced from the center line CL. As a result, in the comparative example, a rotational moment indicated by arrow 8A acts on the carrier 25, and therefore, when the carrier 25 is transported, behavior of the carrier 25 is apt to be unstable.

[0068]

On the other hand, in the configuration of the exemplary embodiment, since such a rotational moment is hard to act on the carrier 25, behavior of the carrier 25 becomes stable and vibrations of the carrier 25 have come to be suppressed. To describe specifically, in the exemplary embodiment, a supporting structure of the carrier 25 (a structure of the carrier guide 25 is line symmetry with respect to a center line of the carrier 25 (a vertical line that passes through the center of gravity G of the carrier 25) as an axis of symmetry as shown in FIG. 7, and accordingly, generation of the rotational moment is suppressed, to thereby cause the carrier 25 to be supported in more stable state.

[0069]

Moreover, in the comparative example, as shown in FIG. 8, at a contact portion between the first rotating body 216 and the supported portion 25B, the first rotating body 216 and the supported portion 25B make point contact. In such a case, support of the carrier 25 becomes unstable, and thereby the carrier 25 is apt to vibrate. Moreover, when the first rotating body 216 and the supported portion 25B make the point contact, the first rotating body 216 and the supported portion 25B tend to wear, and more wear particles are generated.

[0070]

On the other hand, in the configuration of the exemplary embodiment, as shown in FIG. 7, the first roll-like member 911 and the first rod-like member 310 make line contact, and the second roll-like member 912 and the second rod-like member 320 also make the line contact. To additionally describe, a contact portion between the first roll-like member 911 and the first rod-like member 310 and a contact portion between the second roll-like member 912 and the second rod-like member 320 form a linear shape.

[0071]

To describe further, in the exemplary embodiment, the first support surface 7X contacts an outer circumferential surface of the hollow-cylindrical rotating body 911A provided in the first roll-like member 911 and the second support surface 7Y contacts an outer circumferential surface of the hollow-cylindrical rotating body 912A provided in the second roll-like member 912, and accordingly, the contact portion between the first roll-like member 911 and the first rod-like member 310 and the contact portion between the second roll-like member 912 and the second rod-like member 320 form the linear shape. In this case, the carrier 25 is stably supported and vibrations of the carrier 25 have come to be suppressed. Moreover, in this case, generation of the wear particles has come to be suppressed.

[0072]

Further, in the configuration of the exemplary embodiment, compared to the comparative example, weight reduction of the carrier 25 is sought. Specifically, as shown in FIG. 3, a through hole 98 is formed between two lower roll pairs 92 that are adjacent to each other, and the carrier 25 becomes lighter in weight by forming the through hole 98.

Here, in the configuration of the comparative example, since the lower portion of the carrier 25 is guided by the second rotating body 217 (refer to FIG. 8) and the third rotating body 218, it is difficult to form through holes in the lower portion of the carrier 25. On the other hand, since the exemplary embodiment has the configuration in which the lower roll pairs 92 are guided, it becomes possible to form the through hole 98 between the adjacent lower roll pairs 92.

[0073]

Here, the present inventor conducted experiments on the configuration of the exemplary embodiment and the configuration of the above-described comparative example, to make an investigation of the vibrations (vibrations acceleration) of the carrier 25.

FIG. 10 is a diagram showing vibrations of the carrier 25 in the exemplary embodiment and vibrations of the carrier 25 in the comparative example.

It should be noted that, in the figure, “peak” means a maximum value of measured vibrations acceleration. Moreover, “average” means an average value of the measured vibrations acceleration. Moreover, in the figure, “height direction” indicates vibrations acceleration of the carrier 25 in the height direction of the carrier 25, “proceeding direction” indicates the vibrations acceleration of the carrier 25 in the proceeding direction of the carrier 25, and “thickness direction” indicates the vibrations acceleration of the carrier 25 in the thickness direction of the carrier 25.

[0074]

To describe experimental results with reference to FIG. 10, as shown in the figure, in both peak and average, the vibrations acceleration was smaller in the configuration of the exemplary embodiment than in the

configuration of the comparative example. In particular, with respect to the peak value, the value of the vibrations acceleration in the configuration of the exemplary embodiment was $1/3$ to $1/5$ compared to that of the comparative example.

5 [0075]

(Others)

In the above description, the case in which the first roll-like member 911 and the second roll-like member 912 were shifted from each other in the transporting direction of the carrier 25 in each of the upper roll pairs 91 was
10 described as an example. This is because, in the exemplary embodiment, the thickness of the carrier 25 is small, and therefore, it is impossible to set the first roll-like member 911 and the second roll-like member 912 at the same location. Here, in a case where the thickness of the carrier 25 is large, the first roll-like member 911 and the second roll-like member 912 may be
15 set at a same location.

[0076]

To additionally describe, in the case where the first roll-like member 911 and the second roll-like member 912 are shifted from each other in the transporting direction of the carrier 25 as in the exemplary embodiment, it is
20 possible to reduce the thickness of the carrier 25. On the other hand, in the case where the first roll-like member 911 and the second roll-like member 912 are provided at the same location, it is required to increase thickness of the carrier 25.

[0077]

25 Moreover, in the above description, the case in which the inclination angle of each of the first support surface 7X and the second support surface 7Y with respect to the horizontal direction was set at 45° and the inclination

angles of the rotational shafts 911B and 912B provided in the upper roll pair 91 (refer to FIG. 4) with respect to the horizontal direction were set at 45° was described as an example; however, the inclination angles are merely an example, and the inclination angle may be other than 45°, namely, 30°, 60° or the like.

[0078]

It should be noted that, according to a result of a running test of the carrier 25 conducted by the present inventor, the inclination angle with respect to the horizontal direction is preferably 35°-55° (45°±10°), and more preferably in a range of 40°-50° (45°±5°).

[0079]

Here, if the inclination angle becomes less than 35°, the first horizontal-direction load 7B and the second horizontal-direction load 7C described in FIG. 7 are reduced by the order of ten percent compared to the case where the inclination angle is 45°. Moreover, if the inclination angle becomes less than 35°, it becomes difficult to suppress vibrations of the carrier 25 in the height direction of the carrier 25.

Moreover, if the inclination angle becomes more than 55°, the first horizontal-direction load 7B and the second horizontal-direction load 7C described in FIG. 7 are similarly reduced by the order of ten percent compared to the case where the inclination angle is 45°. Moreover, if the inclination angle becomes more than 55°, it becomes difficult to suppress vibrations of the carrier 25 in the thickness direction of the carrier 25.

[0080]

It should be noted that, in the above description, the case in which the first horizontal-direction load 7B and the second horizontal-direction load 7C were generated by use of the first rod-like member 310 and the

second rod-like member 320 that are inclined with respect to the horizontal direction was described as an example; however, the first horizontal-direction load 7B and the second horizontal-direction load 7C can be generated not only by the rod-like members like these but also by
5 providing a rotating body like the rotating body 911A shown in FIG. 4 at each of one lateral side and the other lateral side of the transporting route of the carrier 25. It should be noted that, in this case, the rotational shaft of the rotating body is inclined to cause a portion of an outer circumferential surface of the rotating body for supporting the carrier 25 to be inclined with
10 respect to the horizontal direction. Moreover, in this case, a portion of the carrier 25 with which the outer circumferential surface is brought into contact is inclined with respect to the horizontal direction.

Reference Signs List

- 15 [0081]
7X ... First support surface
7Y ... Second support surface
25 ... Carrier
80 ... Substrate (Non-magnetic substrate)
20 200 ... Manufacturing apparatus (Film-forming apparatus)
210U ... Upper carrier guide
250 ... Carrier main body
911 ... First roll-like member
911A ... Rotating body
25 911B ... Rotational shaft
912 ... Second roll-like member
912A ... Rotating body

912B ... Rotational shaft

CLAIMS

1. A film-forming apparatus comprising:

a guiding mechanism that guides a carrier transported along a transporting route while holding a substrate on which a film-forming process is performed, wherein

the guiding mechanism comprises:

a first support surface that is arranged on one lateral side of the transporting route and supports a part of the carrier transported on the transporting route from beneath; and

a second support surface that is arranged on an opposite side of the first support surface across the transporting route and supports a part of the carrier transported on the transporting route from beneath, and wherein

the first support surface is provided with a tilt descending toward a side where the second support surface is provided, and the second support surface is provided with a tilt descending toward a side where the first support surface is provided.

2. The film-forming apparatus according to claim 1, wherein

the first support surface is arranged on the one lateral side of the transporting route and is arranged along the transporting route to support the part of the carrier transported on the transporting route from beneath and to guide the part, and

the second support surface is arranged on the other lateral side of the transporting route and is arranged along the transporting route to support the part of the carrier transported on the transporting route from

beneath and to guide the part.

3. The film-forming apparatus according to claim 2, wherein each of a portion of the carrier to be supported by the first support surface and a
5 portion of the carrier to be supported by the second support surface is provided with a rotating member.

4. The film-forming apparatus according to claim 3, wherein,
of the carrier, the portion to be supported by the first support
10 surface is provided with a first rotating member that rotates around a rotational shaft having one end and the other end, and the portion to be supported by the second support surface is provided with a second rotating member that rotates around a rotational shaft having one end and the other end,

15 the first rotating member is arranged so that the one end of the rotational shaft is positioned at the transporting route side and the other end of the rotational shaft is positioned at the one lateral side, and the other end is positioned above the one end to incline the rotational shaft with respect to a horizontal direction, and

20 the second rotating member is arranged so that the one end of the rotational shaft is positioned at the transporting route side and the other end of the rotational shaft is positioned at the other lateral side, and the other end is positioned above the one end to incline the rotational shaft with respect to the horizontal direction.

25 5. The film-forming apparatus according to claim 4, wherein
each of the first rotating member and the second rotating member

comprises a hollow-cylindrical rotating body,

the first support surface contacts an outer circumferential surface of the rotating body of the first rotating member from beneath to support the first rotating member, and

5 the second support surface contacts an outer circumferential surface of the rotating body of the second rotating member from beneath to support the second rotating member.

6. The film-forming apparatus according to any one of claims 1 to 5,
10 wherein, of the carrier, the portion to be supported by the first support surface and the portion to be supported by the second support surface are located above a center of gravity of the carrier.

7. A carrier, to which a substrate to be subjected to a film-forming
15 process is attached, transported along a transporting route provided in a film-forming apparatus while being guided by a guiding portion provided on one lateral side of the transporting route and a guiding portion provided on the other lateral side of the transporting route, the carrier comprising:

a carrier main body, to which the substrate is attached, that is
20 transported on the transporting route in the film-forming apparatus;

a first rotating member that is provided rotatably around a rotational shaft having one end and the other end, and is guided by the guiding portion provided at the one lateral side while being supported from beneath when the carrier main body is transported on the transporting
25 route; and

a second rotating member that is provided rotatably around a rotational shaft having one end and the other end, and is guided by the

guiding portion provided at the other lateral side while being supported from beneath when the carrier main body is transported on the transporting route, wherein,

the first rotating member is arranged so that, when the carrier main body is transported on the transporting route, the one end of the rotational shaft is positioned at the transporting route side and the other end is positioned at the one lateral side, and the other end is positioned above the one end to incline the rotational shaft with respect to a horizontal direction, and

the second rotating member is arranged so that, when the carrier main body is transported on the transporting route, the one end of the rotational shaft is positioned at the transporting route side and the other end is positioned at the other lateral side, and the other end is positioned above the one end to incline the rotational shaft with respect to the horizontal direction.

8. The carrier according to claim 7, wherein the first rotating member and the second rotating member are provided so that setting positions of the first rotating member and the second rotating member are different from each other in a transporting direction when the carrier main body is transported on the transporting route.

9. A method of manufacturing a substrate on which a film is formed, in which a carrier holding a substrate is transported and a film-forming process is performed on the substrate to manufacture a film-forming substrate that is a substrate to be subjected to the film-forming process, the method comprising:

when the carrier is transported, guiding the carrier by a guiding mechanism that guides the carrier to transport the carrier along a predetermined transporting route, wherein

the guiding mechanism comprises:

5 a first support surface that is arranged on one lateral side of the transporting route and supports a part of the carrier transported on the transporting route from beneath; and

10 a second support surface that is arranged on an opposite side of the first support surface across the transporting route and supports a part of the carrier transported on the transporting route from beneath, and wherein

15 the first support surface is provided with a tilt descending toward a side where the second support surface is provided, and the second support surface is provided with a tilt descending toward a side where the first support surface is provided.