

PRESSURE MONITORING APPARATUS, SEMICONDUCTOR CLEANING EQUIPMENT, AND MONITORING METHOD THEREOF

FIELD OF THE INVENTION

The present application mainly relates to the semiconductor field, and in particular, to a pressure monitoring apparatus, a semiconductor cleaning equipment, and a monitoring method thereof.

BACKGROUND

A semiconductor cleaning process mainly uses a specific cleaning brush to scrub and clean residues, dust, dirt, etc., on a wafer. During the cleaning process, the brush is in direct contact with the wafer, and the force exerted by the brush on the wafer surface is crucial to the cleaning effect. If the force exerted by the brush on the wafer is too large, the wafer is likely to be crushed; if the force is too small, the cleaning effect on the wafer cannot be achieved. Currently, no effective or accurate solution exists for monitoring the pressure between a brush head and the wafer in semiconductor cleaning equipment.

SUMMARY

A technical problem to be solved by the present application is the inaccurate monitoring of the contact pressure between the brush head and the wafer during the wafer cleaning process.

To solve the above technical problem, the present application provides a pressure monitoring apparatus for monitoring the pressure borne by a force-receiving element of a device under test, comprising: a mounting frame, used to fixedly connect the pressure monitoring apparatus to the device under test; a swing rod, rotatably connected to the mounting frame, a force-receiving element being located on a first side of the swing rod; and a pressure sensor, located on a second side of the swing rod, and the first side and the second side being arranged opposite to each other. When the swing rod is stressed, the swing rod swings between the force-receiving element and the pressure sensor; the swing rod is provided with a first pressure contact portion and

a second pressure contact portion, the first pressure contact portion is protrudingly arranged toward the first side, and the second pressure contact portion is protrudingly arranged toward the second side and is in contact with the pressure sensor. Wherein, when the force-receiving element receives pressure, the pressure is transmitted to the first pressure contact portion and makes the swing rod swing, so that the second pressure contact portion transmits the pressure to the pressure sensor.

Another aspect of the present application further provides a semiconductor cleaning equipment, comprising: a brush assembly and the pressure monitoring apparatus as described above. Wherein, the brush assembly includes a brush head, a brush head connecting member, and a brush body frame. The brush head connecting member includes a movable shaft, the movable shaft has a first end and a second end, the brush head is fixedly connected to the second end of the movable shaft, and the movable shaft is movably connected to the brush body frame, so that the movable shaft can move along a third direction, and the third direction is the axial direction of the movable shaft. Wherein, the pressure monitoring apparatus is disposed on one side of the first end of the movable shaft, both the mounting frame and the pressure sensor are fixedly connected to the brush body frame, the first end of the movable shaft is in direct or indirect contact with the first pressure contact portion, the brush head is the force-receiving element, and when the brush head receives pressure, the movable shaft moves along the third direction and transmits the pressure to the first pressure contact portion.

Another aspect of the present application further provides a monitoring method applied to the semiconductor cleaning equipment as described above, comprising: adjusting the contact between the second pressure contact portion and the pressure sensor, so that the measured value of the pressure sensor is an initial pressure value; starting the semiconductor cleaning equipment and acquiring the measured value of the pressure sensor; monitoring the working state of the semiconductor cleaning equipment according to the measured value.

The pressure monitoring apparatus of the present application receives pressure from a force-receiving element through a first pressure contact portion and transmits the pressure to a pressure sensor through a second pressure contact portion, enabling accurate monitoring of the pressure of the force-receiving element. In addition, the

pressure monitoring apparatus can be flexibly installed on a device under test. When applied to a semiconductor cleaning equipment, the pressure monitoring apparatus can accurately monitor the pressure borne by a brush head, including the contact pressure between the brush head and a wafer during the cleaning process. And the pressure monitoring apparatus can be used to monitor multiple working states of the semiconductor cleaning equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and performance of the present application are further described by the following embodiments and the accompanying drawings of the embodiments.

FIG. 1 is a schematic three-dimensional view of a partial structure of a pressure monitoring apparatus according to an embodiment of the present application;

FIG. 2 is a side view of a pressure monitoring apparatus according to an embodiment of the present application;

FIG. 3 is a top view of the embodiment shown in FIG. 1;

FIG. 4 is a cross-sectional view taken along line BB in FIG. 3;

FIG. 5 is a cross-sectional view taken along line CC in FIG. 3;

FIG. 6 is a schematic three-dimensional view of a partial structure of a semiconductor cleaning equipment according to an embodiment of the present application;

FIG. 7 is a schematic three-dimensional view of a partial structure of a semiconductor cleaning equipment according to an embodiment of the present application;

FIG. 8 is a cross-sectional view taken along line AA in FIG. 6;

FIG. 9 is a schematic structural view of a buffer member in a semiconductor cleaning equipment according to an embodiment of the present application;

FIG. 10 is an exemplary flowchart of a monitoring method according to an embodiment of the present application;

FIG. 11 is a schematic view of calculating the indentation amount in a monitoring method according to an embodiment of the present application;

FIG. 12 is a schematic view of a brush head swinging process in a monitoring method according to an embodiment of the present application.

PREFERRED EMBODIMENTS OF THE INVENTION

To further clarify the technical solutions of the embodiments of the present application, the accompanying drawings required for describing the embodiments will be briefly introduced below. Obviously, the accompanying drawings described below are only some examples or embodiments of the present application. For those of ordinary skill in the art, the present application can also be applied to other similar scenarios according to these accompanying drawings without making creative efforts. Unless clearly indicated by the context or otherwise stated, the same reference numerals in the figures represent the same structures or operations.

As shown in the present application, unless the context clearly indicates exceptions, the words "a," "an," "one," and/or "the" do not specifically refer to the singular and may include the plural. Generally speaking, the terms "comprise" and "include" only indicate that the clearly identified steps and elements are included, and these steps and elements do not constitute an exclusive list. The method or device may also include other steps or elements.

Unless otherwise specifically stated, the relative arrangements of components and steps, numerical expressions, and numerical values set forth in these embodiments do not limit the scope of the present application. At the same time, it should be understood that for the convenience of description, the sizes of various portions shown in the accompanying drawings are not drawn according to the actual proportional relationship. The technologies, methods, and devices known to those of ordinary skill in the relevant fields may not be discussed in detail, but where appropriate, the technologies, methods, and devices should be regarded as part of the authorized

specification. In all examples shown and discussed herein, any specific value should be interpreted as merely exemplary and not as a limitation. Therefore, other examples of the exemplary embodiments may have different values. It should be noted that similar reference numerals and letters denote similar items in the following accompanying drawings, so once an item is defined in one accompanying drawing, the item does not need to be further discussed in subsequent accompanying drawings.

In the description of the present application, it should be understood that orientation words such as "front, rear, upper, lower, left, right," "transverse, longitudinal, vertical, horizontal," and "top, bottom" generally indicate the orientation or positional relationship based on the orientation or positional relationship shown in the accompanying drawings, which is only for the convenience of describing the present application and simplifying the description. Unless stated to the contrary, these orientation words do not indicate or imply that the device or element referred to must have a specific orientation or be constructed and operated in a specific orientation, and therefore cannot be understood as limiting the protection scope of the present application; the orientation words "inner, outer" refer to the inner and outer relative to the outline of each component itself.

For the convenience of description, spatial relative terms such as "above," "on," "on the surface of," and "upper" can be used here to describe the spatial positional relationship between a device or feature and other devices or features, as shown in the figures. It should be understood that the spatial relative terms are intended to include different orientations of the device in use or operation, in addition to the orientation described in the figures. For example, if the device in the figures is turned over, the device described as "above other devices or structures" or "on other devices or structures" will then be defined as "below other devices or structures" or "under other devices or structures". Thus, the exemplary term "above" can include both orientations of "above" and "below". The device can also be positioned in other ways (rotated by 90 degrees or in other orientations), and the spatial relative descriptions used herein should be interpreted accordingly.

In addition, it should be noted that the use of words such as "first" and "second" to define components is only for the convenience of distinguishing corresponding components. Unless otherwise stated, the above words have no special meanings and

therefore cannot be understood as limiting the protection scope of the present application. In addition, although the terms used in the present application are selected from publicly known and commonly used terms, some terms mentioned in the specification of the present application may be selected by the applicant according to his or her judgment, and the detailed meanings of the terms are explained in the relevant portions of the description herein. In addition, the present application requires not only to be understood through the actual terms used but also through the meaning implied by each term.

The present application uses a flowchart to illustrate the operations performed by the system according to the embodiments of the present application. It should be understood that the operations described above or below may not necessarily be performed in the exact order presented. Instead, multiple steps can be processed in reverse order or simultaneously. At the same time, other operations can be added to these processes, or a step or several steps can be removed from these processes.

The pressure monitoring apparatus of the present application can be used to monitor the pressure borne by a force-receiving element of a device under test. The pressure monitoring apparatus can be installed on any device under test and can directly or indirectly obtain the pressure transmitted from the force-receiving element. Preferably, the pressure monitoring apparatus is installed on the semiconductor cleaning equipment of the present application to monitor the pressure values of a brush head in the semiconductor cleaning equipment during idling, swinging, and wafer cleaning. The monitoring result is accurate, which is conducive to monitoring the device under test according to the monitoring result and further adjusting the brush head and the process.

FIG. 1 is a schematic three-dimensional view of a partial structure of a pressure monitoring apparatus according to an embodiment of the present application. FIG. 2 is a side view of a pressure monitoring apparatus according to an embodiment of the present application. FIG. 3 is a top view of the embodiment shown in FIG. 1. FIG. 4 is a cross-sectional view taken along line BB in FIG. 3, and FIG. 5 is a cross-sectional view taken along line CC in FIG. 3.

According to FIGS. 1 to 5, the pressure monitoring apparatus 100 of this

embodiment comprises a mounting frame 110, a swing rod 130, and a pressure sensor 140. Wherein, the mounting frame 110 is used to fixedly connect the pressure monitoring apparatus 100 to a device under test (not shown). The swing rod 130 is rotatably connected to the mounting frame 110. A force-receiving element (not shown) is located on a first side 131 of the swing rod 130, and the pressure sensor 140 is located on a second side 132 of the swing rod 130. The first side 131 and the second side 132 are arranged opposite to each other. When the swing rod 130 is stressed, the swing rod 130 swings between the force-receiving element and the pressure sensor 140.

In the embodiment shown in FIGS. 1 to 5, the pressure monitoring apparatus 100 is arranged in the direction shown in the figures during actual use, wherein the first side 131 is the downward side of the swing rod 130, and the second side 132 is the upward side of the swing rod 130. In other embodiments, the actual application position of the pressure monitoring apparatus 100 depends on the device under test and can be any direction and any position, and the orientations of the first side 131 and the second side 132 are not limited.

As shown in FIG. 1, the mounting frame 110 is a frame structure having a concave configuration, so that the mounting frame 110 can be fixedly installed on the device under test through the concave frame structure. As shown in FIG. 1, this embodiment further includes a rotating shaft 120. The rotating shaft 120 is rotatably connected to the mounting frame 110 through a bearing. The rotating shaft 120 is cylindrical, and the swing rod 130 is fixedly arranged on the rotating shaft 120. When the swing rod 130 is stressed, the swing rod 130 can drive the rotating shaft 120 to rotate relative to the mounting frame 110. In other embodiments, the rotating shaft 120 can be fixedly arranged between the two side walls of the mounting frame 110. The swing rod 130 has a connecting block 133 for rotationally connected to the rotating shaft 120. The connecting block 133 has a through hole, so that the connecting block 133 is sleeved on the rotating shaft 120. The connecting block 133 can rotate around the rotating shaft 120. The swing rod 130 further includes a rod body 300 connected to or integrally formed with the connecting block 133. A first pressure contact portion 210 and a second pressure contact portion 220 are both arranged on the rod body 300. Specifically, the rod body 300 is flat and has a certain thickness. As shown in FIG. 1, in this embodiment, the rod body 300 has a first support rod 310 extending along a first

direction D1 and a second support rod 320 extending along a second direction D2. The first pressure contact portion 210 is arranged on the first support rod 310, and the second pressure contact portion 220 is arranged on the second support rod 320. The first direction D1 is perpendicular to the second direction D2. According to FIG. 3, if the connection portion between the connecting block 133 and the rotating shaft 120 is taken as a fulcrum, the moment arm from the first pressure contact portion 210 to the fulcrum is a first distance L1, and the moment arm from the second pressure contact portion 220 to the fulcrum is a second distance L2. The first distance L1 is shorter than the second distance L2. Correspondingly, when the swing rod 130 rotates around the rotating shaft 120, according to the moment balance, the pressure F1 received by the first pressure contact portion 210 should be greater than the pressure F2 transmitted by the second pressure contact portion 220 to the pressure sensor 140. Preferably, the first distance L1 is equal to the second distance L2, $F1 = F2$, and the pressure F2 measured by the pressure sensor 140 is F1.

In other embodiments, the specific relationships between the first direction D1 and the second direction D2, and between the first distance L1 and the second distance L2 are not limited. The shapes, sizes, and positional relationships of the mounting frame 110 and the swing rod 130 can be adaptively set according to the shape and size of the installation space.

As shown in FIG. 2, the first pressure contact portion 210 is protrudingly arranged toward the first side 131, and the second pressure contact portion 220 is protrudingly arranged toward the second side 132. In FIG. 2, a certain gap exists between the second pressure contact portion 220 and the pressure sensor 140, indicating that the distance between the second pressure contact portion 220 and the pressure sensor 140 is adjustable. The pressure sensor 140 itself can be fixedly arranged on the device under test, for example, fixedly connected to a certain portion of the device under test through the top 141 of the pressure sensor 140. In actual use, the protruding portion of the second pressure contact portion 220 is in direct contact with the pressure sensor 140, so that the pressure sensor 140 can sense the pressure borne by the protruding portion of the second pressure contact portion 220.

In actual use, the protruding portion of the first pressure contact portion 210 is in direct or indirect contact with the force-receiving element. When the force-receiving

element receives pressure, the pressure is transmitted to the first pressure contact portion 210 and makes the swing rod 130 swing toward the pressure sensor 140, driving the second pressure contact portion 220 to move, so that the second pressure contact portion 220 transmits the pressure to the pressure sensor 140, thereby monitoring the force received by the force-receiving element through the pressure sensor 140.

According to FIG. 4, in this embodiment, the swing rod 130 is provided with a first groove 410. The first pressure contact portion 210 includes a first contact ball 211. The first contact ball 211 is arranged in the first groove 410 and partially protrudes from the first groove 410. As shown in FIG. 4, the diameter of the first groove 410 is equivalent to or slightly larger than the diameter of the first contact ball 211, so that the first contact ball 211 can rotate freely inside the first groove 410. At the same time, the opening of the first groove 410 is small and smaller than the diameter of the first contact ball 211, so that the first contact ball 211 cannot come out of the first groove 410. In some embodiments, the first groove 410 is a counterbore set on the swing rod 130 and does not penetrate the swing rod 130, so the first contact ball 211 is limited in the first groove 410. In the embodiment shown in FIG. 4, the first groove 410 is a through hole penetrating the swing rod 130, and a first baffle 420 is further provided at the bottom of the first groove 410 to limit the position of the first contact ball 211 in the first groove 410. The first groove 410 and the first baffle 420 together limit the first contact ball 211 in a certain space. Within this space, the first contact ball 211 can freely rotate around the center of the first contact ball 211 without translation. As shown in FIG. 1, a first opening 421 is provided at the portion of the first baffle 420 corresponding to the first contact ball 211. The diameter of the first opening 421 is smaller than the diameter of the first contact ball 211, so that the first contact ball 211 can rotate freely while being limited in the internal space of the first groove 410. In some embodiments, the diameter of the first opening 421 gradually decreases from top to bottom, as shown in FIG. 1.

According to FIG. 5, in this embodiment, the swing rod 130 is provided with a second groove 510. The second pressure contact portion 220 includes a second contact ball 221. The second contact ball 221 is arranged in the second groove 510 and partially protrudes from the second groove 510. As shown in FIG. 5, the second groove 510 is

composed of a through hole penetrating the swing rod 130 and a second baffle 520. The opening of the second groove 510 is smaller than the diameter of the second contact ball 221 to limit the second contact ball 221 in a certain space in the second groove 510. Within this space, the second contact ball 221 can freely rotate around the center of the second contact ball 221 without translation. In other embodiments, the second groove 510 can be a counterbore directly set on the swing rod 130, and then it is unnecessary to additionally provide the second baffle 520.

Similar to the first baffle 420, in some embodiments, a second opening is also provided at the portion of the second baffle 520 corresponding to the second contact ball 221. The diameter of the second opening is smaller than the diameter of the second contact ball 221, so that the second contact ball 221 can rotate freely while being limited in the internal space of the second groove 510. In some embodiments, the diameter of the second opening gradually decreases from bottom to top.

In some embodiments, both the first contact ball 211 and the second contact ball 221 can be metal balls, such as steel balls. The present application does not limit the size and number of the first contact ball 211 and the second contact ball 221. For example, the first pressure contact portion 210 may include a plurality of first contact balls 211, each first contact ball 211 corresponds to a first groove 410, and the plurality of first grooves 410 are arranged close to each other on the first support rod 310. For another example, the swing rod 130 may include a plurality of first support rods arranged in parallel, each first support rod is provided with a set of first grooves and first contact balls, or each first support rod is provided with a first groove, and a first contact ball is arranged in one of the first grooves. The installation position of the first contact ball can be determined according to the actual spatial position and the structure of the device under test. Similarly, the second pressure contact portion 220 may include a plurality of second contact balls 221, each second contact ball 221 corresponds to a second groove 510, the plurality of second grooves 510 are arranged close to each other on the second support rod 320, or a second contact ball is arranged in only one of the second grooves. In practical applications, only one first contact ball 211 and one second contact ball 221 are arranged in the pressure monitoring apparatus 100.

By arranging the first contact ball 211 and the second contact ball 221 that can freely rotate, the spherical surface characteristics of the first contact ball 211 and

second contact ball 221 are used to create point contact with the force-receiving element or the pressure sensor 140, which can receive forces in various directions borne by the force-receiving element directly or indirectly connected to the first contact ball 211, and transmit the forces in various directions to the pressure sensing surface of the pressure sensor 140 in the vertical direction, thereby obtaining an accurate pressure measurement value. At the same time, due to the connection relationship between the device under test and the force-receiving element, the force generated by the device under test during operation due to swinging, vibration, etc., affects the force-receiving element and can be transmitted to the first contact ball 211 through the force-receiving element.

According to FIG. 4, in some embodiments, a buffer pad 430 is provided at the bottom of the first groove 410, and the buffer pad 430 is located between the first contact ball 211 and the first baffle 420. Similarly, although not shown, in some embodiments, a buffer pad is also provided at the bottom of the second groove 510.

The material of the buffer pad should have the function of buffering the applied stress, for example, the material may be a flexible, elastic material such as plastic, rubber, felt pad, etc., used to increase the force stability, without affecting the free rotation of the first contact ball 211 and the second contact ball 221 at the same time, and can eliminate the high-frequency vibration generated by the device under test during operation to a certain extent, remove high-frequency noise, and reduce the impact of device vibration on the pressure measurement.

To achieve a buffering effect similar to the buffering effect of the buffer pad, the following specific embodiments can be adopted: A buffer layer made of a buffer material is provided on the surface of the first contact ball 211 and/or the second contact ball 221, and the buffer layer can wrap the entire surface of the sphere, or may be located only in a certain area of the surface of the sphere; the first contact ball 211 and/or the second contact ball 221 are made of a buffer material; a first contact portion where the force-receiving element contacts the first contact ball 211 includes a buffer material; the pressure sensor 140 includes a second contact portion in contact with the second contact ball 221, and the second contact portion includes a buffer material.

FIG. 6 is a schematic three-dimensional view of a partial structure of a

semiconductor cleaning equipment according to an embodiment of the present application. FIG. 7 is a schematic three-dimensional view of a partial structure of a semiconductor cleaning equipment according to an embodiment of the present application, with some components omitted compared to FIG. 6. FIG. 8 is a cross-sectional view taken along line AA in FIG. 6. According to FIGS. 6 to 8, the semiconductor cleaning equipment 600 of this embodiment includes a brush assembly 610 and the pressure monitoring apparatus 100 described above. Wherein, the brush assembly 610 includes a brush head 6110, a brush head connecting member 6120, and a brush body frame 6130. As shown in FIG. 8, the brush head connecting member 6120 includes a movable shaft 6121. The movable shaft 6121 has a first end 6121a and a second end 6121b. The brush head 6110 is fixedly connected to the second end 6121b of the movable shaft 6121. The movable shaft 6121 is movably connected to the brush body frame 6130, so that the movable shaft 6121 can move along a third direction D3, and the third direction D3 is the axial direction of the movable shaft 6121. The pressure monitoring apparatus 100 is disposed on one side of the first end 6121a of the movable shaft 6121, both the mounting frame 110 and the pressure sensor 140 are fixedly connected to the brush body frame 6130, the first end 6121a of the movable shaft 6121 is in direct or indirect contact with the first pressure contact portion 210, the brush head 6110 is the force-receiving element, and when the brush head 6110 receives pressure, the movable shaft 6121 moves along the third direction D3 and transmits the pressure to the first pressure contact portion 210.

Specifically, in some embodiments, the brush assembly 610 further includes a first driving assembly 6140 and a fixed frame 6150. The first driving assembly 6140 is fixed on the fixed frame 6150 and is used to drive the brush body frame 6130 to move between a reference position and a processing position along the third direction D3. The reference position and the processing position will be described later. According to FIGS. 6 to 8, the fixed frame 6150 includes a first fixing plate 6151 and a second fixing plate 6152. The first driving assembly 6140 is fixed below the first fixing plate 6151. As shown in FIG. 8, the first driving assembly 6140 includes a guide rail 6141 and a telescopic member 6142. The guide rail 6141 is arranged to extend along the third direction D3, and the telescopic member 6142 may specifically be a cylinder. The brush body frame 6130 includes an upper end plate 6131, a vertical plate 6132, and a lower end plate 6133. The three plates are sequentially connected in a Z-

shape. Wherein, the vertical plate 6132 has a protruding portion 6132a connected to the guide rail 6141, and the protruding portion 6132a can slide along the guide rail 6141. The lower end of the telescopic member 6142 is fixedly connected to the lower end plate 6133. When the telescopic member 6142 is driven to extend downward, the telescopic member 6142 pushes the lower end plate 6133 downward, thereby driving the entire brush body frame 6130 to move downward. When the telescopic member 6142 is driven to retract upward, the telescopic member 6142 drives the lower end plate 6133 upward, thereby driving the entire brush body frame 6130 to move upward.

Furthermore, the brush assembly 610 further includes a second driving assembly 6160. The second driving assembly 6160 is disposed on the brush body frame 6130 and is used to drive the movable shaft 6121 to rotate, thereby driving the brush head 6110 to rotate. In some embodiments, the second driving assembly 6160 includes a motor 6161, a driving pulley 6162, a driven pulley 6163, and a transmission belt 6164. When the motor 6161 rotates, the driving pulley 6162 is driven to rotate, thereby further driving the driven pulley 6163 to rotate through the transmission belt 6164. As shown in FIG. 8, the driven pulley 6163 is disposed on the outer circumference of the movable shaft 6121 and connected to the movable shaft 6121 through a spline sleeve 6165, which can drive the movable shaft 6121 to rotate, thereby driving the brush head 6110 to rotate. In FIG. 8, the motor 6161 is carried above the lower end plate 6133, the driving pulley 6162 is disposed below the lower end plate 6133, and a connecting bearing between the motor 6161 and the driving pulley 6162 can penetrate the lower end plate 6133. The brush body frame 6130 further includes a first side plate 6134. The spline sleeve 6165 is rotatably mounted on the first side plate 6134 of the brush body frame 6130 through a bearing, so that the driven pulley 6163 is mounted on the brush body frame 6130 through the spline sleeve 6165. According to this arrangement, when the first driving assembly 6140 drives the brush body frame 6130 to move along the third direction D3, the second driving assembly 6160 is also moved at the same time, so that the brush head 6110 can be driven to rotate by the second driving assembly 6160 regardless of the position of the brush head 6110 in the third direction D3.

In the embodiment shown in FIGS. 6 to 8, during the cleaning process, the wafer is located below the brush head 6110. In other embodiments, the wafer may be located above the brush head 6110, and the semiconductor cleaning equipment can be turned

upside down based on the embodiment shown in FIG. 6. This specification takes the embodiment shown in FIG. 6 as an example for description and is not intended to limit the arrangement direction of the semiconductor cleaning equipment.

According to FIGS. 6 to 8, the pressure monitoring apparatus 100 is disposed on one side of the first end 6121a of the movable shaft 6121, that is, above the movable shaft 6121. Both the mounting frame 110 and the pressure sensor 140 in the pressure monitoring apparatus 100 are fixedly connected to the upper end plate 6131. The first end 6121a of the movable shaft 6121 is in direct or indirect contact with the first pressure contact portion 210. The brush head 6110 is the force-receiving element. When the brush head 6110 receives pressure, the movable shaft 6121 moves upward and transmits the pressure to the first pressure contact portion 210, thereby further transmitting the pressure to the second pressure contact portion 220 to be sensed by the pressure sensor 140.

According to FIG. 7, in some embodiments, the brush head connecting member 6120 further includes a first movable plate 6122. The first movable plate 6122 is disposed at the first end 6121a of the movable shaft 6121 and directly contacts the first pressure contact portion 210. The first end 6121a of the movable shaft 6121 is in indirect contact with the first pressure contact portion 210 through the first movable plate 6122.

According to FIG. 8, in some embodiments, the brush assembly 610 further includes elastic connecting members 6170. The brush head connecting member 6120 further includes a second movable plate 6123. The second movable plate 6123 is disposed at the second end 6121b of the movable shaft 6121. The elastic connecting members 6170 are connected between the brush body frame 6130 and the second movable plate 6123, so that the movable shaft 6121 is movably connected to the brush body frame 6130. Specifically, the elastic connecting members 6170 may be implemented as springs and include at least two springs, as shown in FIG. 8. Furthermore, as shown in FIGS. 6 and 8, the first side plate 6134 and the upper end plate 6131 of the brush body frame 6130 are provided with fittings 6135 suitable for installing the elastic connecting members 6170, such as hooks. Correspondingly, as shown in FIGS. 7 and 8, the second movable plate 6123 is also provided with fittings 6125 suitable for installing the elastic connecting members 6170. As shown in FIGS.

6 and 7, the brush head connecting member 6120 further includes a second side plate 6124 connected between the first movable plate 6122 and the second movable plate 6123 to limit the rotation of the first movable plate 6122 and the second movable plate 6123. According to this arrangement, when the brush head 6110 receives upward pressure, the elastic connecting members 6170 are compressed and rebound. At the same time, the first movable plate 6122, the second movable plate 6123, and the movable shaft 6121 move upward as a whole, transmitting the pressure to the first pressure contact portion 210.

As described above, according to the characteristics of the pressure monitoring apparatus 100 of the present application, during the cleaning process performed by the semiconductor cleaning equipment 600 of the present application, the pressure monitoring apparatus 100 of the present application can be used to accurately monitor the pressure received by the brush head 6110. It should be noted that the semiconductor cleaning equipment 600 may also include other fixed structures, conventional structures, etc., and is not limited to the structure shown in FIG. 6.

According to FIGS. 6 and 8, the semiconductor cleaning equipment 600 of this embodiment further includes a buffer member 630 installed on the fixed frame 6150. Specifically, as shown in FIG. 6, the lower end of the buffer member 630 is fixedly disposed on the second fixing plate 6152 in the fixed frame 6150. When the brush body frame 6130 moves downward along the guide rail 6141 to a certain position, the upper end of the buffer member 630 contacts the lower end plate 6133. The buffer member 630 is used to reduce the speed of the brush body frame 6130 moving downward. The specific position is set according to process requirements to ensure a certain safe distance between the wafer and the brush head 6110. When the distance between the brush head 6110 and the wafer reaches the safe distance, the descending speed should be reduced, and the pressure should be accurately measured to avoid fragmentation, which is not specifically limited in the present application. In some embodiments, the certain position corresponds to the position of the brush body frame 6130 when the brush head 6110 extends downward but has not reached the processing position.

The present application does not limit the specific structure of the buffer member 630, which can be any structure with a buffering function.

FIG. 9 is a schematic structural view of a buffer member in a semiconductor cleaning equipment according to an embodiment of the present application. According to FIG. 9, the buffer member 630 of this embodiment includes a buffer bracket 910, a buffer pin 920, and an elastic member 930. One end of the buffer bracket 910 is installed on the second fixing plate 6152 in the fixed frame 6150. The buffer bracket 910 has a hollow structure, and the elastic member 930 is disposed in the hollow structure. The buffer pin 920 has a pin rod 921 and a pin head 922 connected to each other. The pin rod 921 is partially disposed in the hollow structure, and the pin head 922 is located at the other end of the buffer bracket 910 for contacting the brush body frame 6130 when the brush body frame 6130 moves. Specifically, the elastic member 930 may be a spring. A spring cover 931 may also be provided at the bottom of the elastic member 930. The spring cover 931 is disposed at the bottom of the buffer bracket 910 to block the lower end opening of the buffer bracket 910 and clamp the elastic member 930. The size of the pin head 922 should be appropriate to have a certain area and thickness to contact the lower end plate 6133 in the brush body frame 6130 to bear the downward pressure.

Furthermore, the second fixing plate 6152 is provided with a threaded mounting hole 940 having a certain height. The buffer bracket 910 is inserted into the threaded mounting hole 940, and the height of the buffer bracket 910 entering the threaded mounting hole 940 is limited by a lock nut 941, thereby limiting the overall height of the buffer member 630.

In application, the lifting and lowering of the brush head 6110, driven by the first driving assembly 6140, will cause fluctuations in the pressure received by the brush head 6110. The provision of the buffer member 630 can improve this problem, make the contact force between the brush head 6110 and the wafer more stable, and avoid wafer damage.

According to FIG. 8, in some embodiments, the brush assembly 610 further includes a limiting member 640, and the limiting member 640 may be installed on the fixed frame 6150, for example, on the back surface of the guide rail 6141 below the first fixing plate 6151. When the brush body frame 6130 moves downward, the limiting member 640 can contact the upper end plate 6131 to prevent the brush body frame 6130 from moving further downward. The limiting member 640 limits the extended

position of the brush head 6110 by limiting the position of the brush body frame 6130. For example, this position may be the limit position where the brush head 6110 extends downward.

The semiconductor cleaning equipment 600 of the present application is provided with the pressure monitoring apparatus 100, and the pressure monitoring apparatus 100 can accurately monitor the pressure borne by the brush head 6110 for monitoring and controlling the semiconductor cleaning equipment 600.

Applying the semiconductor cleaning equipment 600 described above in the present application, the present application further provides a monitoring method. As shown in FIG. 10, the monitoring method comprises the following steps:

Step S10: Adjust the contact between the second pressure contact portion 220 and the pressure sensor 140, so that the measured value of the pressure sensor 140 is an initial pressure value. The initial pressure value is a non-zero value and is not smaller than a set value, so that the contact point between the second contact ball and the pressure sensor 140 is stable, and the accuracy of pressure monitoring is prevented from being affected by abnormal vibration. If the initial pressure value is smaller than the set value, the elastic connecting members 6170 need to be replaced. In step S10, by selecting an appropriate type of elastic connecting members 6170, the deformation caused by the self-weight of the brush assembly 610 can be overcome, and the compression degree between the second contact ball and the pressure sensor 140 can be changed.

Step S20: Start the semiconductor cleaning equipment 600 and acquire the measured value of the pressure sensor 140.

Step S30: Monitor the working state of the semiconductor cleaning equipment 600 according to the measured value.

The monitoring method of the present application can monitor multiple working states of the semiconductor cleaning equipment 600. Since the pressure sensor 140 can accurately measure the pressure borne by the brush head 6110 in any working state, the working state of the semiconductor cleaning equipment 600 can be effectively

monitored.

In some embodiments, the monitored working state is the indentation amount of the brush head. According to FIG. 11, assuming that when the brush head 6110 is at a reference position P1, a first distance H1 exists between the brush head 6110 and a wafer W. During the cleaning process, the brush head 6110 is at a processing position P2, and a second distance H2 exists between the reference position P1 and the processing position P2. The indentation amount is equal to H2 minus H1. It can be understood that different indentation amounts result in different pressures between the brush head 6110 and the wafer W. To monitor the indentation amount, step S20 in the monitoring method specifically comprises the following steps:

Step S2010: Acquire measured values of the pressure sensor 140 during the cleaning process, denoted as process values.

According to FIG. 8, the wafer cleaning equipment 600 may further include a swing mechanism 650 for swinging the brush assembly 610. During the cleaning process, the brush assembly 610 is swung along a certain path, and at the same time, the brush head 6110 is driven to rotate by the second driving assembly 6160 and driven to the processing position by the first driving assembly 6140, so that the brush head 6110 contacts the wafer surface.

Step S2011: Use an average value of a plurality of process values obtained through multiple measurements as the monitoring pressure.

In the test phase, step S2010 can be performed cyclically to obtain the average value of the plurality of process values.

Step S2012: Acquire the relationship between different indentation amounts and the monitoring pressure.

The monitoring pressures at multiple indentation amounts can be obtained through testing, thereby establishing the relationship between the indentation amounts and the monitoring pressure, for example, a relationship curve or a relationship list can be obtained. In some embodiments, the functional relationship between the indentation

amounts and the monitoring pressure can be obtained by linear fitting:

$$y = k * x + b \quad (1)$$

Wherein, y represents the monitoring pressure, x represents the indentation amount, k and b are linear fitting coefficients, k represents the pressure change rate, and b is a constant. In other embodiments, a quadratic function, a non-linear function, etc., can also be used to obtain the fitted functional relationship.

Step S2013: During the cleaning process, obtain the current monitoring pressure, and obtain the current indentation amount corresponding to the current monitoring pressure according to the relationship obtained in step S2012.

The current indentation amount of the brush head 6110 during the cleaning process can be obtained in real time through steps S2010 to S2013.

In other embodiments, to monitor the indentation amount, step S20 in the monitoring method includes:

Step S2020: Acquire the measured value of the pressure sensor 140 when the brush head 6110 is idling, denoted as a start-up value. At this time, the brush head 6110 does not contact the wafer and does not swing.

Step S2021: Acquire measured values of the pressure sensor 140 during the cleaning process, denoted as process values;

Step S2022: Use a difference between an average value of the process values and the start-up value as the monitoring pressure. When $L1$ is equal to $L2$ in FIG. 3, the difference between the average value of the process values and the start-up value can directly characterize the pressure borne by the brush head 6110.

Step S2023: Acquire the relationship between different indentation amounts and the monitoring pressure;

Step S2024: During the cleaning process, obtain the current monitoring pressure, and obtain the current indentation amount corresponding to the current monitoring

pressure according to the relationship.

Wherein, steps S2021, S2023, and S2024 are the same as steps S2010, S2012, and S2013 respectively, and will not be expanded.

In some embodiments, the target indentation amount required for the wafer cleaning process can be obtained, the target monitoring pressure can be calculated according to the above relationship (1), and the extension length of the brush head 6110 can be adjusted, so that the current monitoring pressure is equal to the target monitoring pressure, forming a closed-loop control with a feedback mechanism.

In some embodiments, the working state of the semiconductor cleaning equipment 600 includes the relative levelness between the brush head 6110 and the wafer W. To monitor the relative levelness, step S20 includes: acquiring a plurality of measured values when the brush head 6110 is at different positions on the wafer W, and determining whether the relative levelness between the brush head 6110 and the wafer W is normal according to the differences between the plurality of measured values. Specifically, a normal range can be preset. If the difference is within the normal range, it indicates that the relative levelness is acceptable, and no intervention is needed; if the difference is outside the normal range, it indicates that the relative levelness is unacceptable, and the position of the brush head 6110 or the wafer W need to be adjusted, and the adjusted relative levelness can be determined through subsequent measured values. Furthermore, the way to adjust the brush head 6110 or the wafer W can be determined according to the size of the measured value at a certain position. For example, the pressure corresponding to the position A of the brush head 6110 on the wafer W is relatively large, indicating that the distance between the brush head 6110 and the wafer W is close. The pressure corresponding to the position B of the brush head on the wafer W is relatively small, indicating that the distance between the brush head 6110 and the wafer W is far. When it is determined that the relative levelness is unacceptable, the horizontal position of the brush head 6110 or the wafer W is adjusted, such as tilting the wafer W to move the position A of the wafer W away from the brush head, or moving the position B of the wafer W closer to the brush head 6110.

It should be noted that when the relative levelness is monitored, the brush head 6110 is respectively arranged at a plurality of different positions on the wafer W. The

brush head 6110 is controlled to extend to contact the wafer W, and the brush head 6110 can be rotating or non-rotating.

In some embodiments, the working state of the semiconductor cleaning equipment 600 includes whether the structure of the brush assembly is abnormal. As shown in FIGS. 6 to 8, the structure of the brush assembly 610 is asymmetric. When the structure is normal, the brush assembly 610 is in a balanced state. However, if the structure is abnormal, imbalance will occur, thereby affecting the performance of the device. For this reason, step S20 includes: acquiring measured values of the pressure sensor 140 during the idling of the brush head 6110 for a period of time, denoted as dynamic start-up values, and determining whether the structure of the brush assembly 610 is abnormal according to the fluctuation range of the dynamic start-up values. At this time, the brush head 6110 does not contact the wafer and does not swing. A normal range can be preset. If the fluctuation range of the dynamic start-up values is within the normal range, it indicates that the structure of the brush assembly 610 is normal; otherwise, it indicates that the structure of the brush assembly 610 is abnormal.

In some embodiments, the working state of the semiconductor cleaning equipment 600 includes whether the swing of the brush assembly 610 is abnormal. According to FIG. 12, during the process, the position of the wafer W is usually fixed. The brush assembly 610 can be controlled to swing between positions P3 and P4 by the swing mechanism 650 shown in FIG. 8, and the wafer W is located on the swing path. To detect whether the swing is abnormal, the brush head 6110 can be controlled not to rotate and not to contact the wafer W. The brush head 6110 is controlled to swing between positions P3 and P4, and the measured values during this period are acquired. A normal range is preset. If the fluctuation range of the measured values is within the normal range, it indicates that the swing of the brush assembly 610 is normal; otherwise, it indicates that the swing of the brush assembly 610 is abnormal.

It should be noted that in the embodiment of monitoring the indentation amount of the brush head 6110, during the cleaning process, when the brush head 6110 swings from position P3 into contact with the wafer W, and during the process when the brush head 6110 leaves the wafer W and is swung to position P4, the pressure measurement values fluctuate greatly. The measurement values obtained during these two intervals are not utilized for determining the working state, and only the measurement values

when the brush head 6110 is completely in contact with the wafer W are selected as the process values.

The basic concepts have been described above. Obviously, for those skilled in the art, the above application disclosure is only an example and does not constitute a limitation to the present application. Although not explicitly stated here, those skilled in the art may make various modifications, improvements, and corrections to the present application. Such modifications, improvements, and corrections are suggested in the present application, so such modifications, improvements, and corrections still belong to the spirit and scope of the exemplary embodiments of the present application.

At the same time, the present application uses specific words to describe the embodiments of the present application. For example, "one embodiment," "an embodiment," and/or "some embodiments" mean a certain feature, structure, or characteristic related to at least one embodiment of the present application. Therefore, it should be emphasized and noted that the "one embodiment" or "an embodiment" or "an alternative embodiment" mentioned twice or more in different positions in this specification does not necessarily refer to the same embodiment. In addition, some features, structures, or characteristics in one or more embodiments of the present application can be appropriately combined.

Similarly, it should be noted that, in order to simplify the expression of the disclosure of the present application and thereby help understand one or more invention embodiments, in the foregoing description of the embodiments of the present application, multiple features are sometimes combined into one embodiment, accompanying drawing, or description thereof. However, this disclosure method does not mean that the object of the present application requires more features than the features mentioned in the claims. In fact, the features of the embodiments are fewer than all the features of a single embodiment disclosed above.

Some embodiments employ numerical values to describe the quantity of components and attributes. It should be understood that such numerical values used for describing the embodiments are modified by the modifier "about," "approximately," or "substantially" in some examples. Unless otherwise stated, "about," "approximately," or "substantially" indicates that the number allows a variation of $\pm 20\%$. Accordingly,

in some embodiments, the numerical parameters used in the present application are approximate values, and the approximate values can be changed according to the required characteristics of individual embodiments. In some embodiments, the numerical parameters should consider the specified effective digits and adopt the general method of retaining the significant digits. Although the numerical ranges and parameters used to confirm the breadth of the scope in some embodiments of the present application are approximate values, in specific embodiments, such numerical values are set as accurately as possible within the feasible range.

What is claimed is:

1. A pressure monitoring apparatus, for monitoring the pressure borne by a force-receiving element of a device under test, comprising a mounting frame, a swing rod, and a pressure sensor;

the mounting frame being used to fixedly connect the pressure monitoring apparatus to the device under test;

the swing rod being rotatably connected to the mounting frame, the force-receiving element being located on a first side of the swing rod, the pressure sensor being located on a second side of the swing rod, the first side and the second side being arranged opposite to each other, and when the swing rod is stressed, the swing rod swinging between the force-receiving element and the pressure sensor;

the swing rod being provided with a first pressure contact portion and a second pressure contact portion, the first pressure contact portion being protrudingly arranged toward the first side, and the second pressure contact portion being protrudingly arranged toward the second side and being in contact with the pressure sensor;

wherein, when the force-receiving element receives pressure, the pressure is transmitted to the first pressure contact portion and makes the swing rod swing, so that the second pressure contact portion transmits the pressure to the pressure sensor.

2. The pressure monitoring apparatus according to claim 1, wherein the swing rod includes a first groove, the first pressure contact portion includes a first contact ball, the first contact ball is arranged in the first groove and partially protrudes from the first groove, and the first contact ball can rotate freely in the first groove.

3. The pressure monitoring apparatus according to claim 2, wherein the swing rod includes a second groove, the second pressure contact portion includes a second contact ball, the second contact ball is arranged in the second groove and partially protrudes from the second groove, and the second contact ball can rotate freely in the second groove.

4. The pressure monitoring apparatus according to claim 3, wherein a buffer pad

is provided at the bottom of the first groove and/or the bottom of the second groove.

5. The pressure monitoring apparatus according to claim 3, wherein a buffer layer is provided on the surface of the first contact ball and/or the surface of the second contact ball, and the buffer layer includes a buffer material.

6. The pressure monitoring apparatus according to claim 3, wherein the first contact ball and/or the second contact ball is a metal ball.

7. The pressure monitoring apparatus according to claim 3, wherein the first contact ball and/or the second contact ball includes a buffer material.

8. The pressure monitoring apparatus according to claim 3, wherein the force-receiving element includes a first contact portion in contact with the first contact ball, and the first contact portion includes a buffer material.

9. The pressure monitoring apparatus according to claim 3, wherein the pressure sensor includes a second contact portion in contact with the second contact ball, and the second contact portion includes a buffer material.

10. A semiconductor cleaning equipment, comprising: a brush assembly and the pressure monitoring apparatus according to any one of claims 1 to 9, wherein the brush assembly includes a brush head, a brush head connecting member, and a brush body frame, the brush head connecting member includes a movable shaft, the movable shaft has a first end and a second end, the brush head is fixedly connected to the second end of the movable shaft, the movable shaft is movably connected to the brush body frame, so that the movable shaft can move along a third direction, and the third direction is the axial direction of the movable shaft;

the pressure monitoring apparatus is disposed on one side of the first end of the movable shaft, both the mounting frame and the pressure sensor are fixedly connected to the brush body frame, the first end of the movable shaft is in direct or indirect contact with the first pressure contact portion, the brush head is the force-receiving element, and when the brush head receives pressure, the movable shaft moves along the third direction and transmits the pressure to the first pressure contact portion.

11. The semiconductor cleaning equipment according to claim 10, wherein the brush head connecting member further includes a first movable plate, the first movable plate is disposed at the first end of the movable shaft and directly contacts the first pressure contact portion, and the first end of the movable shaft is in indirect contact with the first pressure contact portion through the first movable plate.

12. The semiconductor cleaning equipment according to claim 11, wherein the brush assembly further includes an elastic connecting member, the brush head connecting member further includes a second movable plate, the second movable plate is disposed at the second end of the movable shaft, and the elastic connecting member is connected between the brush body frame and the second movable plate, so that the movable shaft is movably connected to the brush body frame.

13. The semiconductor cleaning equipment according to claim 10, wherein the brush assembly further includes a first driving assembly and a fixed frame, the first driving assembly is fixed on the fixed frame and is used to drive the brush body frame to move between a reference position and a processing position along the third direction.

14. The semiconductor cleaning equipment according to claim 13, wherein the brush assembly further includes a second driving assembly, and the second driving assembly is disposed on the brush body frame and is used to drive the movable shaft to rotate.

15. The semiconductor cleaning equipment according to claim 13, wherein the semiconductor cleaning equipment further comprises a buffer member installed on the fixed frame for reducing the moving speed of the brush body frame.

16. The semiconductor cleaning equipment according to claim 15, wherein the buffer member includes a buffer bracket, a buffer pin, and an elastic member, one end of the buffer bracket is installed on the fixed frame, the buffer bracket has a hollow structure, the elastic member is disposed in the hollow structure, the buffer pin has a pin rod and a pin head connected to each other, the pin rod is partially disposed in the hollow structure, and the pin head is located at the other end of the buffer bracket for contacting the brush body frame when the brush body frame moves.

17. A monitoring method applied to the semiconductor cleaning equipment according to any one of claims 10 to 16, comprising:

adjusting the contact between the second pressure contact portion and the pressure sensor, so that the measured value of the pressure sensor is an initial pressure value;

starting the semiconductor cleaning equipment and acquiring the measured value of the pressure sensor;

monitoring the working state of the semiconductor cleaning equipment according to the measured value.

18. The monitoring method according to claim 17, wherein the working state includes the indentation amount of the brush head, when the brush head is not cleaning a wafer, the brush head is at a retracted reference position, a first distance exists between the brush head and the wafer at this time; when the brush head is cleaning the wafer, the brush head is at an extended processing position, a second distance exists between the extended position and the reference position; the indentation amount is the second distance minus the first distance; the step of starting the semiconductor cleaning equipment and acquiring the measured value of the pressure sensor in the monitoring method includes:

acquiring the measured value of the pressure sensor during the cleaning process, denoted as process values;

using an average value of a plurality of process values obtained through multiple measurements as the monitoring pressure;

acquiring the relationship between different indentation amounts and the monitoring pressure;

during the cleaning process, obtaining the current monitoring pressure, and obtaining the current indentation amount corresponding to the current monitoring pressure according to the relationship.

19. The monitoring method according to claim 17, wherein the working state

includes the indentation amount of the brush head, when the brush head is not cleaning a wafer, the brush head is at a retracted reference position, a first distance exists between the brush head and the wafer at this time; when the brush head is cleaning the wafer, the brush head is at an extended processing position, a second distance exists between the extended position and the reference position; the indentation amount is the second distance minus the first distance; the step of starting the semiconductor cleaning equipment and acquiring the measured value of the pressure sensor in the monitoring method further includes:

acquiring the measured value of the pressure sensor when the brush head is idling, denoted as a start-up value;

acquiring the measured value of the pressure sensor during the cleaning process, denoted as process values;

using a difference between an average value of the process values and the start-up value as the monitoring pressure;

acquiring the relationship between different indentation amounts and the monitoring pressure;

during the cleaning process, obtaining the current monitoring pressure, and obtaining the current indentation amount corresponding to the current monitoring pressure according to the relationship.

20. The monitoring method according to claim 18 or 19, further comprising:

acquiring the target indentation amount required for the wafer cleaning process, and calculating the target monitoring pressure according to the relationship;

adjusting the extension length of the brush head, so that the current monitoring pressure is equal to the target monitoring pressure.

21. The monitoring method according to claim 17, wherein the working state includes the relative levelness between the brush head and a wafer, and the step of starting the semiconductor cleaning equipment and acquiring the measured value of

the pressure sensor in the monitoring method includes:

acquiring a plurality of measured values when the brush head is at different positions on the wafer, and determining the relative levelness between the brush head and the wafer according to the differences between the plurality of measured values.

22. The monitoring method according to claim 17, wherein the working state includes whether the structure of the brush assembly is abnormal, and the step of starting the semiconductor cleaning equipment and acquiring the measured value of the pressure sensor in the monitoring method includes:

acquiring the measured value of the pressure sensor during the idling of the brush head for a period of time, denoted as dynamic start-up values, and determining whether the structure of the brush assembly is abnormal according to the fluctuation range of the dynamic start-up values.

23. The monitoring method according to claim 17, wherein the working state includes whether the swing of the brush assembly is abnormal, and the step of starting the semiconductor cleaning equipment and acquiring the measured value of the pressure sensor in the monitoring method includes:

when the brush head is not rotating, swinging the brush head and obtaining the measured value during the swinging process, and determining whether the swing of the brush assembly is abnormal according to the fluctuation range of the measured values.