SUBSTRATE CLEANING DEVICE AND METHOD

TECHNICAL FIELD

The present invention relates to the technical field of semiconductor equipment, and in particular to a substrate cleaning device and a substrate cleaning method.

BACKGROUND

Semiconductor cleaning is an important process step throughout the entire wafer manufacturing process. Current semiconductor cleaning devices are divided into two types: batch-type cleaning devices and single-wafer cleaning devices. Batch-type cleaning devices are used for batch-type wet cleaning of wafers, providing high production efficiency. Single-wafer cleaning devices are used for single-wafer wet cleaning, providing high cleaning quality.

The cleaning control of existing single-wafer cleaning devices is uniform. The same cleaning parameter is used for substrates with different levels of contamination for cleaning. Substrates with a relatively high level of contamination and substrates with a relatively low level of contamination consume the same amount of cleaning liquid. Typically, the cleaning parameter is set based on the substrates with a relatively high level of contamination. Therefore, for the substrates with a relatively low level of contamination, over-cleaning and waste of cleaning liquid will occur.

SUMMARY

The technical problem to be solved by the present invention is to overcome the above-mentioned defect and provide a substrate cleaning device and a substrate cleaning method.

The present invention solves the technical problem described above through the following technical solutions:

providing a substrate cleaning device, comprising:

a cleaning unit, including a rotating carrier and a cleaning nozzle, the rotating

carrier being used for carrying a substrate and driving the substrate to rotate, and the cleaning nozzle being used for spraying a cleaning liquid onto the substrate to clean the substrate;

a liquid sampling unit, configured to obtain the cleaning liquid on the substrate in real time during the substrate cleaning process;

a detection unit, used for receiving the cleaning liquid obtained by the liquid sampling unit and detecting the cleanliness of the cleaning liquid;

a control unit, communicatively connected to the detection unit, used for controlling the cleaning parameter according to the cleanliness of the cleaning liquid.

In this solution, by adding a liquid sampling unit to obtain the cleaning liquid on the substrate in real time, the cleanliness of the cleaning liquid obtained by the liquid sampling unit can accurately reflect the level of contamination of the current substrate. The detection unit can detect the cleanliness of the cleaning liquid obtained by the liquid sampling unit, and the control unit controls the cleaning parameter according to the cleanliness detected by the detection unit. The substrate cleaning device provided in this embodiment can detect the level of contamination of the current substrate more accurately, thereby enabling smart cleaning based on the level of contamination of the current substrate. For example, if the level of contamination of the substrate is high, the cleaning parameter can be increased; if the level of contamination of the substrate is low, the cleaning parameter can be reduced. This ensures the cleaning quality of the substrate while also reducing the waste of cleaning liquid.

The present invention further provides a substrate cleaning method, comprising:

controlling a substrate to rotate and spraying a cleaning liquid onto the substrate for cleaning;

obtaining the cleaning liquid on the current substrate in real time;

detecting the cleanliness of the cleaning liquid;

controlling the cleaning parameter for the current substrate according to the

cleanliness of the cleaning liquid.

In this solution, by obtaining the cleaning liquid on the current substrate in real time, the cleanliness of the cleaning liquid can reflect the level of contamination of the substrate, thereby enabling real-time detection of the level of contamination of the current substrate. Consequently, smart cleaning can be performed according to the level of contamination of the current substrate, ensuring the cleaning quality of the substrate while also reducing the waste of cleaning liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a schematic diagram of the substrate cleaning device according to Embodiment 1 of the present invention;

FIG. 2 is a schematic diagram of the substrate cleaning device according to Embodiment 2 of the present invention;

FIG. 3 is a schematic diagram of the substrate cleaning device according to Embodiment 3 of the present invention;

FIG. 4 is a schematic diagram of the substrate cleaning device according to Embodiment 4 of the present invention; and

FIG. 5 is a flowchart of the substrate cleaning method according to Embodiment 5 of the present invention.

PREFERRED EMBODIMENTS OF THE APPLICATION

The present invention will be further illustrated below by way of embodiments, but the present invention is not thereby limited to the scope of the embodiments.

Embodiment 1

As shown in FIG. 1, this embodiment provides a substrate cleaning device, comprising a cleaning chamber 100, a cleaning unit, a liquid sampling unit 140, a detection unit 200, and a control unit 300. The cleaning unit and the liquid sampling unit 140 are both disposed within the cleaning chamber 100. The cleaning unit includes a rotating carrier 110 and a cleaning nozzle 130, wherein the rotating carrier 110 is used for carrying a substrate W and driving the substrate W to rotate, and the cleaning nozzle 130 is used for spraying a cleaning liquid onto the substrate W to clean the substrate W. The liquid sampling unit 140 is configured to obtain the cleaning liquid on the substrate W in real time during the cleaning process of the substrate W. The detection unit 200 is used for receiving the cleaning liquid obtained by the liquid sampling unit 140 and detecting the cleanliness of the cleaning liquid. The control unit 300 is communicatively connected to the detection unit 200, and the control unit 300 is used for controlling the cleaning parameter according to the cleanliness of the cleaning liquid. Wherein, the cleaning parameter includes any one or more of cleaning time, cleaning pressure, cleaning flow rate, and the rotation speed of the rotating carrier 110.

The substrate cleaning device provided in this embodiment is a single-wafer cleaning device. A liquid discharge pipeline 150 is provided at the bottom of the cleaning chamber 100, and the cleaning liquid after being used for cleaning the substrate W is discharged through the liquid discharge pipeline 150. A delay is present in the cleaning liquid discharged from the liquid discharge pipeline 150, and cleaning liquid from a previous substrate W after cleaning may remain. If liquid is directly sampled from the liquid discharge pipeline 150 for cleanliness analysis, the level of contamination of the current substrate W cannot be accurately reflected. In this embodiment, by adding the liquid sampling unit 140 to obtain the cleaning liquid on the substrate W in real time, the cleanliness of the cleaning liquid obtained by the liquid sampling unit 140 can reflect the level of contamination of the current substrate W more accurately. The detection unit 200 can detect the cleanliness of the cleaning liquid obtained by the liquid sampling unit 140, and the control unit 300 controls the cleaning parameter according to the cleanliness detected by the detection unit 200. The substrate cleaning device provided in this embodiment can detect the level of contamination of the current substrate more accurately, thereby enabling smart cleaning based on the level of contamination of the current substrate W. For example, if the level of

contamination of the substrate W is high, the cleaning parameter can be increased (e.g., increasing cleaning flow rate, cleaning pressure, and cleaning time); if the level of contamination of the substrate W is low, the cleaning parameter can be reduced (e.g., reducing cleaning flow rate, cleaning pressure, and cleaning time). This ensures the cleaning quality of the substrate W while also reducing the waste of cleaning liquid.

Specifically, in this embodiment, the liquid sampling unit 140 is a liquid sampler, such as a vacuum suction nozzle device, which obtains liquid by generating negative pressure and is disposed at a position above the edge region of the substrate W. The device can suck the cleaning liquid from the surface of the substrate W in a non-contact manner, making it less likely to cause damage to the substrate W. In some embodiments, the liquid sampler may also use a suction head connected to a pump via a pipeline for liquid sampling.

The detection unit 200 is a particle counter. The particle counter is an existing device. The liquid inlet of the particle counter is connected to the liquid sampling unit 140, the liquid outlet of the particle counter is connected to the liquid discharge pipeline 150, and the signal output end of the particle counter is connected to the control unit 300. The particle counter can convert the number of particles into an electrical signal and transmit the signal to the control unit 300. The number of particles in the cleaning liquid can be obtained via the particle counter, and the cleanliness of the cleaning liquid can be reflected by the number of particles.

In some embodiments, the detection unit 200 may also be other devices capable of detecting the cleanliness of the cleaning liquid, such as a reflective sensor, an electrical property monitoring device, etc.

In this embodiment, the control unit 300 uses a processor for control, such as a PLC controller, a microcontroller unit (MCU), etc.

In this embodiment, the substrate cleaning device further comprises a liquid supply pipeline 400, a regulating valve 410, and a pump 500. One end of the liquid supply pipeline 400 is connected to the cleaning nozzle 130, and the other end of the liquid supply pipeline 400 is connected to the pump 500. The regulating valve 410 is provided on the liquid supply pipeline 400. The control unit 300 is communicatively

connected to the pump 500 and/or the regulating valve 410. The control unit 300 controls the cleaning parameter by controlling the output power of the pump 500 and/or the opening degree of the regulating valve 410.

In this embodiment, the substrate cleaning device further comprises a pressure sensor 420 and a flow rate sensor 430, respectively disposed on the liquid supply pipeline 400. The pressure sensor 420 is communicatively connected to the control unit 300, and the pressure sensor 420 is used for detecting the cleaning pressure of the cleaning liquid within the liquid supply pipeline 400. The flow rate sensor 430 is communicatively connected to the control unit 300, and the flow rate sensor 430 is used for detecting the cleaning flow rate of the cleaning liquid within the liquid supply pipeline 400.

In some embodiments, only the pressure sensor 420 or the flow rate sensor 430 may be provided as needed.

In this embodiment, the substrate cleaning device further comprises a cleaning brush (not shown in the figure), the cleaning brush is used for brushing the surface of the substrate. The control unit 300 is also communicatively connected to the rotating carrier 110 to control the rotation speed of the rotating carrier 110. When it is detected that the level of contamination of the substrate W is relatively high, the rotation speed of the rotating carrier 110 can be increased to improve the cleaning capability for the substrate W.

The communicative connection in this embodiment may be wired or wireless.

Embodiment 2

The substrate cleaning device in this embodiment is substantially the same as the solution in embodiment 1, with the difference lying in the structure of the liquid sampling unit. As shown in FIG. 2, the cleaning unit in this embodiment further includes a protective cover 120. The liquid sampling unit includes a liquid sampling chamber 160. The protective cover 120 is disposed around the outer periphery of the rotating carrier 110. The liquid sampling chamber 160 is disposed around the outer periphery of the protective cover 120. A liquid sampling hole 161 is provided at the

bottom of the liquid sampling chamber 160. The protective cover 120 is provided with an opening 121 in communication with the liquid sampling chamber 160. The opening 121 is configured to allow the cleaning liquid flung off from the substrate W to enter the liquid sampling chamber 160 through the opening 121 during the cleaning of the substrate W. The detection unit 200 is connected to the liquid sampling hole 161, and is used for receiving the cleaning liquid within the liquid sampling chamber 160 and detecting the cleanliness of the cleaning liquid.

The rotating carrier 110 drives the substrate W to rotate, and the cleaning nozzle 130 sprays the cleaning liquid onto the substrate W to clean the substrate W. The cleaning liquid is flung outward in all directions by centrifugal force. The protective cover 120 is disposed around the outer periphery of the rotating carrier 110, preventing the cleaning liquid from corroding components outside the protective cover 120. The protective cover 120 is provided with the opening 121 in communication with the liquid sampling chamber 160. A large amount of the cleaning liquid is discharged from the liquid discharge pipeline 150 at the bottom of the cleaning chamber 100, and a small amount of the cleaning liquid enters the liquid sampling chamber 160 through the opening 121. The amount of cleaning liquid entering the liquid sampling chamber 160 is small, and the discharge speed is high, making the cleaning liquid less likely to remain. During the cleaning process of the substrate W, the cleaning liquid can be quickly discharged from the liquid sampling hole 161 to the detection unit 200. After the substrate cleaning is completed, the processing liquid within the liquid sampling chamber 160 can be quickly emptied. When a next substrate W is cleaned, the cleaning liquid from the previous substrate W is less likely to remain in the liquid sampling chamber 160, thereby improving the accuracy of the cleanliness detection for the next substrate W.

In some embodiments, a cleaner (not shown in the figure), such as a cleaning nozzle, is further provided within the liquid sampling chamber 160 for cleaning the cleaning liquid remaining in the liquid sampling chamber 160. Specifically, the liquid sampling chamber 160 can be cleaned during the replacement of the substrate W to remove the remaining cleaning liquid within the liquid sampling chamber 160, ensuring the accuracy of the cleanliness detection for the next substrate W.

In this embodiment, the liquid sampling chamber 160 completely surrounds the

protective cover 120.

In some embodiments, the liquid sampling chamber 160 may also partially surround the protective cover 120. The volume of the liquid sampling chamber 160 is smaller, and the amount of cleaning liquid entering the liquid sampling chamber 160 is correspondingly reduced. Therefore, the cleaning liquid can be discharged from the liquid sampling chamber 160 more quickly.

Embodiment 3

This embodiment is substantially the same as the solution in embodiment 2, with the difference being that, as shown in FIG. 3, the bottom of the liquid sampling chamber 160 has a drainage slope, so that the bottom of the liquid sampling chamber 160 has a lowest point. The liquid sampling hole 161 is provided at the lowest point of the liquid sampling chamber 160, which is beneficial for accelerating the discharge of the cleaning liquid.

Specifically, the bottom of the liquid sampling chamber 160 includes a groove 162. The opening diameter of the groove 162 decreases from top to bottom to form the drainage slope. The bottom of the groove 162 is the lowest point of the liquid sampling chamber 160. The liquid sampling hole 161 is disposed at the lowest point of the groove 162.

Embodiment 4

This embodiment is substantially the same as the solution in embodiment 2, with the difference being that, as shown in FIG. 4, no protective cover is provided in this embodiment. The liquid sampling chamber 160 is disposed around the outer periphery of the rotating carrier 110. The liquid sampling chamber 160 is configured to allow the cleaning liquid flung off from the substrate W to enter the liquid sampling chamber 160 during the cleaning process of the substrate W.

In this embodiment, the liquid sampling chamber 160 is provided with a liquid inlet hole 163, and the cleaning liquid flung off from the substrate W enters the liquid sampling chamber 160 through the liquid inlet hole 163.

In some embodiments, the top of the liquid sampling chamber 160 is open, and the top of the liquid sampling chamber 160 is lower than the substrate W on the rotating carrier 110. The cleaning liquid flung off from the substrate W enters the liquid sampling chamber 160 through the top of the liquid sampling chamber 160.

Embodiment 5

As shown in FIG. 5, this embodiment provides a substrate cleaning method, comprising:

S10, controlling a substrate to rotate and spraying a cleaning liquid onto the substrate for cleaning;

S20, obtaining the cleaning liquid on the current substrate in real time;

S30, detecting the cleanliness of the cleaning liquid;

S40, controlling the cleaning parameter for the current substrate according to the cleanliness of the cleaning liquid.

By obtaining the cleaning liquid on the current substrate in real time, the cleanliness of the cleaning liquid can reflect the level of contamination of the substrate, thereby enabling real-time detection of the level of contamination of the current substrate. Consequently, smart cleaning can be performed according to the level of contamination of the current substrate, ensuring the cleaning quality of the substrate while also reducing the waste of cleaning liquid.

Although specific embodiments of the present invention have been described above, those skilled in the art should understand that these are merely examples, and the scope of protection of the present invention is defined by the appended claims. Those skilled in the art can make various changes or modifications to these embodiments without departing from the principle and essence of the present invention, and these changes and modifications all fall within the scope of protection of the present invention.

What is claimed is:

1. A substrate cleaning device, comprising:

a cleaning unit, including a rotating carrier and a cleaning nozzle, the rotating carrier being used for carrying a substrate and driving the substrate to rotate, and the cleaning nozzle being used for spraying a cleaning liquid onto the substrate to clean the substrate;

a liquid sampling unit, configured to obtain the cleaning liquid on the substrate in real time during the substrate cleaning process;

a detection unit, used for receiving the cleaning liquid obtained by the liquid sampling unit and detecting the cleanliness of the cleaning liquid;

a control unit, communicatively connected to the detection unit, used for controlling the cleaning parameter according to the cleanliness of the cleaning liquid.

2. The substrate cleaning device according to claim 1, wherein the cleaning parameter includes any one or more of cleaning time, cleaning pressure, cleaning flow rate, and the rotation speed of the rotating carrier.

3. The substrate cleaning device according to claim 2, wherein the substrate cleaning device further comprises a liquid supply pipeline, a regulating valve, and a pump, one end of the liquid supply pipeline is connected to the cleaning nozzle, and the other end of the liquid supply pipeline is connected to the pump, and the regulating valve is provided on the liquid supply pipeline; the control unit is communicatively connected to the pump and/or the regulating valve, and the control unit controls the cleaning parameter by controlling the output power of the pump and/or the opening degree of the regulating valve.

4. The substrate cleaning device according to claim 3, wherein the substrate cleaning device further comprises:

a pressure sensor, disposed on the liquid supply pipeline, communicatively connected to the control unit, used for detecting the cleaning pressure of the cleaning

liquid within the liquid supply pipeline, and/or,

a flow rate sensor, disposed on the liquid supply pipeline, communicatively connected to the control unit, used for detecting the cleaning flow rate of the cleaning liquid within the liquid supply pipeline.

5. The substrate cleaning device according to claim 2, wherein the substrate cleaning device further comprises a cleaning brush, and the cleaning brush is used for brushing the surface of the substrate.

6. The substrate cleaning device according to claim 1, wherein the detection unit is a particle counter.

7. The substrate cleaning device according to claim 1, wherein the liquid sampling unit is a liquid sampler, and the liquid sampler is disposed near the upper surface of the substrate.

8. The substrate cleaning device according to claim 1, wherein the liquid sampling unit includes a liquid sampling chamber disposed around the outer periphery of the rotating carrier, a liquid sampling hole is provided at the bottom of the liquid sampling chamber, and the liquid sampling chamber is configured to allow the cleaning liquid flung off from the substrate to enter the liquid sampling chamber during the substrate cleaning process; the detection unit is connected to the liquid sampling hole.

9. The substrate cleaning device according to claim 8, wherein the substrate cleaning device further comprises a cleaner disposed within the liquid sampling chamber, for cleaning the cleaning liquid remaining in the liquid sampling chamber.

10. The substrate cleaning device according to claim 8, wherein the bottom of the liquid sampling chamber has a drainage slope, so that the bottom of the liquid sampling chamber has a lowest point, and the liquid sampling hole is disposed at the lowest point.

11. The substrate cleaning device according to claim 10, wherein the bottom of the liquid sampling chamber includes a groove, the opening diameter of the groove decreases from top to bottom to form the drainage slope, and the bottom of the groove is the lowest point.

12. The substrate cleaning device according to claim 8, wherein the cleaning unit further includes a protective cover, the protective cover is disposed around the outer periphery of the rotating carrier, the liquid sampling chamber is disposed around the outer periphery of the protective cover, the protective cover is provided with an opening in communication with the liquid sampling chamber, and the opening is configured to allow the cleaning liquid flung off from the substrate to enter the liquid sampling chamber through the opening during the cleaning of the substrate.

13. A substrate cleaning method, comprising:

controlling a substrate to rotate and spraying a cleaning liquid onto the substrate for cleaning;

obtaining the cleaning liquid on the current substrate in real time;

detecting the cleanliness of the cleaning liquid;

controlling the cleaning parameter for the current substrate according to the cleanliness of the cleaning liquid.