

ELECTROPLATING DEVICE AND CLEANING METHOD

FIELD OF THE INVENTION

The present application relates to the field of semiconductor equipment, and in particular relates to an electroplating device and a cleaning method.

BACKGROUND

The substrate electroplating process refers to a process of electroplating metal ions in an electroplating solution onto the surface of a substrate to form metal interconnections in chip manufacturing, such as copper electroplating, nickel electroplating, and tin-silver alloy electroplating.

In existing electroplating devices, a substrate holder includes a conductive pin in contact with the substrate and a sealing member. The conductive pin shall make uniform contact with a seed layer on the front surface of the substrate while being prohibited from direct contact with the electroplating solution, so the sealing member is used for isolation to prevent the electroplating solution from reaching the edge of the front surface of the substrate; otherwise, metal will be electroplated on the edge of the front surface of the substrate and the uniformity of a metal thin film deposited on the substrate will deteriorate. After completion of electroplating, residues such as the residual electroplating solution and electroplated metal often remain on the sealing member.

Taking tin-silver alloy electroplating as an example, residues are generated on the sealing member of the substrate holder during tin-silver alloy electroplating due to the remarkably different reduction potentials between tin atoms and silver atoms. The generation of residues starts with tin plating with low silver content on the surface of the sealing member, followed by the displacement reaction of formula $\text{Sn} + 2\text{Ag}^+ \rightarrow \text{Sn}^{2+} + 2\text{Ag}$ occurring on the surface of the substrate holder, so silver ions are reduced into silver atoms to form silver deposition on the surface of the sealing member.

The document with Patent Application No. 201911077619.1 discloses an electroplating device and a cleaning method, wherein the middle section of a cleaning

pipe arranged inside an electroplating solution storage tank is in contact with the electroplating solution, the middle section of the cleaning pipe is heated by the electroplating solution with a preset temperature to obtain a heated cleaning liquid, and the cleaning liquid with the preset temperature is further used for spray cleaning of the substrate holder to remove residues.

SUMMARY

Aiming at the problem that residues are present on a sealing member of a substrate holder after electroplating treatment on a substrate by an existing electroplating device, the present application provides an electroplating device and a cleaning method.

To solve the above-described problem, the present application provides an electroplating device and a cleaning method.

In some embodiments, the above-described electroplating device comprises:

a process chamber, configured to store an electroplating solution for performing electroplating treatment on a substrate;

a substrate holder, configured to move the substrate into or out of the process chamber, wherein the substrate holder includes a holder main body and a sealing member, the holder main body is used for supporting the substrate, the sealing member isolates the edge of the substrate from the electroplating solution during the electroplating treatment, and the bottom of the sealing member is in contact with the electroplating solution;

a driving system, configured to drive the substrate holder to ascend, lower, and rotate;

a cleaning system, including a nozzle, a cleaning liquid tank, and a cleaning liquid supply pipeline, wherein the cleaning liquid tank supplies a cleaning liquid to the nozzle through the cleaning liquid supply pipeline, the nozzle is provided with an obliquely upward spraying direction to spray the cleaning liquid to a preset position of the substrate and/or the sealing member for cleaning the sealing member, and the spraying direction has a component aligned with the tangential direction of the rotation

direction of the substrate holder at the preset position;

a control system, in communication connection with the driving system and the cleaning system, wherein during cleaning of the sealing member, the control system controls the driving system to lift or lower the substrate holder to a preset height above the nozzle and rotate the substrate holder at a preset rotating speed, and controls the cleaning system to enable the nozzle to spray the cleaning liquid at a preset flow rate.

In some embodiments, the above-described cleaning method comprises:

Step S10: lifting or lowering the substrate holder to a preset height above the nozzle and rotating the substrate holder at a preset rotating speed;

Step S20: enabling the nozzle to spray a first cleaning liquid to a preset position of the substrate and/or the sealing member at a preset flow rate, wherein the spraying direction has a component aligned with the tangential direction of the rotation direction of the substrate holder at the preset position.

Compared with the prior art, in one aspect, the present application timely removes residues on the surface of the sealing member through cleaning by the nozzle of the cleaning system; in another aspect, by arranging the spraying direction of the nozzle to have a component aligned with the tangential direction of the rotation direction of the substrate holder at the preset position and combining the rotating speed of the substrate holder and the spraying flow rate of the nozzle, the cleaning liquid sprayed onto the surface of the substrate and/or the sealing member is thrown radially outward to the maximum extent, the dripping amount of cleaning liquid during cleaning of the sealing member is reduced, and the cleaning liquid is further prevented from dripping into a process tank to contaminate the electroplating solution.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and performance of the present invention will be further described by the following embodiments and the accompanying drawings of the embodiments. Preferred embodiments will be described below in a clear and understandable manner with reference to the accompanying drawings, so as to further explain the above features, technical features, advantages, and implementation manners of the present

invention.

FIG.1 is a schematic view of an electroplating device according to an embodiment of the present application;

FIG.2 is a partial enlarged view of region a in FIG.1;

FIG.3a to FIG.3d are cross-sectional views along cutting line b-b in FIG.1 corresponding to four different embodiments;

FIG.4 is a schematic view along cutting line c-c in FIG.1 according to an embodiment;

FIG.5 is a flow chart of a cleaning method according to an embodiment of the present application.

PREFERRED EMBODIMENTS OF THE PRESENT INVENTION

To further clarify the technical solutions of the embodiments of the present invention or the prior art, the specific embodiments of the present invention will be described below with reference to the accompanying drawings. Obviously, the accompanying drawings described below are merely some embodiments of the present invention, and those of ordinary skill in the art can obtain other accompanying drawings and other embodiments based on these accompanying drawings without making creative efforts.

For simplicity of illustration, only parts relevant to the invention are schematically shown in each drawing, which do not represent actual structures of products. In addition, for simplicity and easy understanding, only one of the components having the same structure or function is schematically shown or marked in some drawings. In this document, "one" may mean not only "only one" but also "more than one."

In the description of the present application, it should be noted that unless otherwise expressly specified and limited, the terms "mount," "interconnect," and "connect" should be understood broadly. For example, the connection can be a fixed connection, a detachable connection, or an integral connection; the connection can be

a mechanical connection or an electrical connection; the connection can be a direct connection, an indirect connection through an intermediate medium, or an internal connection between two elements. For those of ordinary skill in the art, the specific meanings of the above terms in the present invention can be understood according to specific circumstances.

In addition, in the description of the present application, the terms "first," "second," etc. are only used for distinguishing description and shall not be construed as indicating or implying relative importance.

As shown in FIG.1 and FIG.2, an electroplating device 100 according to an embodiment of the present application is disclosed.

Specifically, the electroplating device 100 comprises a process chamber 110, a substrate holder 120, a driving system 130, a cleaning system 140, and a control system 150. Wherein, the process chamber 110 is configured to store an electroplating solution 1112 for electroplating treatment on a substrate 200. The substrate holder 120 is configured to move the substrate 200 into or out of the process chamber 110. With reference to FIG.2, the substrate holder 120 includes a holder main body 121 and a sealing member 123, the holder main body 121 is configured to support the substrate 200, and the sealing member 123 isolates the edge of the substrate 200 from the electroplating solution while the bottom of the sealing member 123 is kept in contact with the electroplating solution during electroplating treatment.

With further reference to FIG.1, the driving system 130 is configured to drive the substrate holder 120 to ascend, lower, and rotate. The cleaning system 140 includes a nozzle 141, a cleaning liquid tank 143, and a cleaning liquid supply pipeline 142. The cleaning liquid tank 143 supplies a cleaning liquid to the nozzle 141 via the cleaning liquid supply pipeline 142, the nozzle 141 is provided with an obliquely upward spraying direction t (as shown in FIG. 4) for spraying the cleaning liquid to a preset position 1412 of the substrate 200 and/or the sealing member 123 to clean the sealing member 123, and the spraying direction t has a component aligned with the tangential direction m of the rotation direction s of the substrate holder 120 at the preset position 1412 as shown in FIG.3a. The control system 150 is in communication connection with the driving system 130 and the cleaning system 140, respectively, during cleaning of

the sealing member 123, the control system 150 controls the driving system 130 to lift or lower the substrate holder 120 to a preset height above the nozzle 141 and rotate the substrate holder 120 at a preset rotating speed, and controls the cleaning system 140 to enable the nozzle 141 to spray the cleaning liquid at a preset flow rate.

In this embodiment, the purpose of configuring the spraying direction t of the nozzle 141 to have a component aligned with the tangential direction m of the rotation direction s of the substrate holder 120 at the preset position 1412 is to avoid counterflow between the spraying direction t of the nozzle 141 and the rotation direction s of the substrate holder 120, so that the cleaning liquid retains a velocity component aligned with the tangential direction m of the rotating direction s of the substrate holder 120 at the preset position 1412 after the nozzle 141 sprays the cleaning liquid onto the substrate 200 and/or the sealing member 123. Combined with the rotating speed of the substrate holder 120 and the spraying flow rate of the nozzle 141, the cleaning liquid sprayed onto the surface of the substrate holder 120 is thrown outward, so as to reduce the dripping amount of cleaning liquid during the cleaning of the sealing member 123, and further prevent the contamination of the electroplating solution 1112 caused by dropped cleaning liquid entering a process tank.

Preferably, as shown in FIG.2, the substrate holder 120 further includes a conductive contact 122 and a pressing plate 124. The holder main body 121 is of annular structure with a substrate supporting portion 1211 extending radially inward from the bottom of the holder main body 121, the sealing member 123 covers the surface of the substrate supporting portion 1211 to isolate the conductive contact 122 and the substrate supporting portion 1211 from the electroplating solution 1112 during electroplating of the substrate 200. The pressing plate 124 moves up and down under the drive of the driving system 130 to fix the substrate 200 between the pressing plate 124 and the substrate supporting portion 1211 while enabling the electrical contact between the conductive contact 122 and the edge of the substrate 200, so the substrate 200 serves as a cathode for electroplating metal layer on the surface of the substrate 200 during electroplating.

Moreover, the substrate holder 120 is further provided with an inner pressure ring 125 and an outer pressure ring 126. The inner pressure ring 125 is locked on the inner peripheral surface 1212 of the holder main body 121, and the outer pressure ring 126

is locked on the outer peripheral surface 1213 of the holder main body 121. The inner pressure ring 125 fixes one side 1231 of the conductive contact 122 and the sealing member 123 between the inner pressure ring 125 and the upper end surface of the substrate supporting portion 1211; the outer pressure ring 126 fixes the other side 1232 of the sealing member 123 between the outer pressure ring 126 and the lower end surface of the substrate supporting portion 1211. In this embodiment, the cleaning area of the cleaning system 140 on the sealing member 123 is concentrated on the bottom of the sealing member 123, including an uncovered bottom segment 1233 of the sealing member 123 not covered by the outer pressure ring 126 and the inner circumferential side 1234 of the sealing member 123. In addition, during cleaning of the sealing member 123, the substrate 200 is mounted on the substrate holder 120 to prevent the nozzle 141 from spraying the cleaning liquid above the substrate holder 120.

Preferably, during the cleaning of the sealing member 123, the substrate 200 supported by the substrate holder 120 is a dummy wafer (test wafer). In practical applications, the substrate 200 includes prime wafers and dummy wafers. A prime wafer is also referred to as a production-grade wafer, which has very few surface and internal defects, an impurity content close to the impurity content of pure silicon, and excellent electrical properties, but is costly to produce. The prime wafer is suitable for the manufacture of semiconductor products. For example, during a substrate electroplating treatment, the substrate 200 supported by the substrate holder 120 is preferably a prime wafer. In contrast, a dummy wafer has more surface and internal defects and a higher impurity content, but is less costly to produce, making the dummy wafer suitable for testing and low-end applications. It should be noted that during an electroplating treatment, since the purity of a dummy wafer cannot meet the process requirements, the substrate 200 can only be a prime wafer for the electroplating treatment. However, during the cleaning of the sealing member 123, if an acidic cleaning liquid is used to clean the sealing member 123, the substrate 200 is preferably a dummy wafer, because the acidic cleaning liquid may damage the plating layer on the surface of a prime wafer. If only pure water is used to clean the sealing member 123, since the pure water has a relatively low impact on the plating layer on the surface of a prime wafer, the substrate 200 may be either a prime wafer or a dummy wafer.

Preferably, the preset rotating speed ranges from 100 revolutions per minute to

400 revolutions per minute, the preset flow rate ranges from 0.5 liter per minute to 1.5 liter per minute, and the included angle α between the spraying direction t and the horizontal plane L ranges from 5 degrees to 30 degrees as shown in FIG.4.

It should be noted that the preset rotating speed, the preset flow rate, and the included angle α between the spraying direction t and the horizontal plane L described above are determined through multiple experiments. In actual operation, multiple test values are first set for the preset rotating speed, the preset flow rate, and the included angle α between the spraying direction t and the horizontal plane L , respectively. These different types of test values are arranged in combinations to form several groups of test values. Testing is then sequentially performed on the electroplating device 100 using each of the above groups of test values, and the total amount of dripping liquid during the cleaning of the sealing member 123 corresponding to the test values of each group is recorded. Finally, the test value ranges where the dripping amount is below a preset value are statistically analyzed to obtain an optimal range.

In the embodiment shown in FIG. 3a, during the cleaning of the sealing member 123, the nozzle 141 sprays the cleaning liquid onto the preset position 1412 of the sealing member 123. At this time, the component of the spraying direction t on the horizontal plane L is in the same direction as the tangential direction m of the rotation direction s on the horizontal plane L at the preset position 1412. In this embodiment, the cleaning liquid is sprayed onto the surface of the sealing member 123 along the spraying direction t , so that the counterflow velocity between the cleaning liquid and the sealing member 123 is at the minimum speed. While rinsing the sealing member 123, the cleaning liquid is thrown outward, thereby reducing the amount of dripping liquid.

In the embodiment shown in FIG. 3b, during the cleaning of the sealing member 123, the nozzle 141 sprays the cleaning liquid onto the preset position 1412 of the sealing member 123. At this time, the included angle β between the component of the spraying direction t on the horizontal plane L and the tangential direction m of the rotation direction s on the horizontal plane L at the preset position 1412 is an acute angle.

In the embodiment shown in FIG. 3c, during the cleaning of the sealing member

123, the nozzle 141 is configured to spray the cleaning liquid onto a region 1413 between the center of the substrate 200 and the sealing member 123, and any position within the region 1413 may serve as the preset position. In this embodiment, the cleaning liquid does not directly rinse the sealing member 123, but during a process in which the cleaning liquid flows outward along the substrate 200, the cleaning liquid passes over the surface of the sealing member 123, thereby cleaning the sealing member 123.

Preferably, in the embodiment shown in FIG. 3d, during the cleaning of the sealing member 123, the nozzle 141 is configured to spray the cleaning liquid onto a region 1414 on the surfaces of the substrate 200 and the sealing member 123, and any position within the region 1414 may serve as the preset position. In this embodiment, a portion of the cleaning liquid is sprayed onto the surface of the substrate 200, and during a process in which this portion of the cleaning liquid flows outward along the substrate 200, the cleaning liquid passes over the surface of the sealing member 123 to clean the sealing member 123; another portion of the cleaning liquid directly rinses the sealing member 123 to clean the sealing member 123.

Specifically, the nozzle 141 is a linear nozzle or a fan-shaped nozzle. It should be noted that, in the embodiments shown in FIGS. 3a and 3b, in order to enable the cleaning liquid to be accurately sprayed onto the surface of the sealing member 123, the nozzle 141 is preferably a linear nozzle. In the embodiment shown in FIG. 3c, since the cleaning liquid only needs to be sprayed onto the region between the center of the substrate 200 and the sealing member 123, the nozzle 141 may be either a linear nozzle or a fan-shaped nozzle. In the embodiment shown in FIG. 3d, since the cleaning liquid needs to be simultaneously sprayed onto the surfaces of the substrate 200 and the sealing member 123, the nozzle 141 is preferably a fan-shaped nozzle.

Preferably, with further reference to FIG. 1, the process chamber 110 includes an inner chamber 111 and an overflow trough 112. Wherein, the inner chamber 111 is used for storing the electroplating solution 1112 and has an opening 1111. The overflow trough 112 is provided surrounding the outer periphery of the opening 1111 for collecting the electroplating solution 1112 overflowing from the inner chamber 111. In addition, a protective cover 113 is provided above the overflow trough 112, and an annular collection groove 1131 is provided on the inner side wall of the protective

cover 113. The annular collection groove 1131 is used for collecting the cleaning liquid thrown out by the substrate holder 120 during the cleaning of the sealing member 123.

As shown in FIG. 5, a cleaning method according to an embodiment of the present application is disclosed. The cleaning method is applicable to the electroplating device 100 of any of the above embodiments.

Specifically, the cleaning method comprises:

Step S10: lifting or lowering the substrate holder 120 to a preset height above the nozzle 141 and driving the substrate holder 120 to rotate at a preset rotating speed;

Step S20: the nozzle 141 spraying a first cleaning liquid onto a preset position of the substrate 200 and/or the sealing member 123 at a preset flow rate, wherein the spraying direction t has a component aligned with the tangential direction m of the rotation direction s of the substrate holder 120 at the preset position.

Preferably, the cleaning method further comprises:

Step S30: switching from the first cleaning liquid to a second cleaning liquid to clean the sealing member 123, wherein the first cleaning liquid is an acidic cleaning liquid, and the second cleaning liquid is pure water.

In practical applications, the sealing member 123 is first cleaned with the acidic cleaning liquid, and then the acidic cleaning liquid is switched to pure water to clean the sealing member 123, so as to remove the acidic cleaning liquid attached to the surface of the sealing member 123, thereby preventing the acidic cleaning liquid attached to the surface of the sealing member from corroding the sealing member after the cleaning of the sealing member is completed. The above-described acidic cleaning liquid includes sulfuric acid, nitric acid, and a mixed solution of sulfuric acid and nitric acid.

It should be noted that the above embodiments may be freely combined as needed. The above are merely preferred embodiments of the present invention. For those of ordinary skill in the art, various improvements and variations may be made without departing from the principles of the present invention, and such improvements and

variations should also be regarded as falling within the protection scope of the present invention.

What is claimed is:

1. An electroplating device, comprising:

a process chamber, configured to store an electroplating solution for performing electroplating treatment on a substrate;

a substrate holder, configured to move the substrate into or out of the process chamber, wherein the substrate holder includes a holder main body and a sealing member, the holder main body is configured to support the substrate, the sealing member isolates the edge of the substrate from the electroplating solution during the electroplating treatment, and the bottom of the sealing member is in contact with the electroplating solution;

a driving system, configured to drive the substrate holder to ascend, lower, and rotate;

a cleaning system, including a nozzle, a cleaning liquid tank, and a cleaning liquid supply pipeline, wherein the cleaning liquid tank supplies a cleaning liquid to the nozzle through the cleaning liquid supply pipeline, the nozzle is provided with an obliquely upward spraying direction to spray the cleaning liquid to a preset position of the substrate and/or the sealing member for cleaning the sealing member, and the spraying direction has a component aligned with the tangential direction of the rotation direction of the substrate holder at the preset position;

a control system, in communication connection with the driving system and the cleaning system, wherein during cleaning of the sealing member, the control system controls the driving system to lift or lower the substrate holder to a preset height above the nozzle and rotate the substrate holder at a preset rotating speed, and controls the cleaning system to enable the nozzle to spray the cleaning liquid at a preset flow rate.

2. The electroplating device according to claim 1, wherein the preset rotating speed ranges from 100 revolutions per minute to 400 revolutions per minute.

3. The electroplating device according to claim 1, wherein the preset flow rate ranges from 0.5 liter per minute to 1.5 liter per minute.

4. The electroplating device according to claim 1, wherein the included angle between the spraying direction and the horizontal plane ranges from 5 degrees to 30 degrees.

5. The electroplating device according to claim 1, wherein a dummy wafer is supported on the holder main body as the carried substrate during cleaning of the sealing member.

6. The electroplating device according to claim 1, wherein during cleaning of the sealing member, a horizontal component of the spraying direction is aligned with the tangential direction of the rotation direction on the horizontal plane at the preset position when the nozzle sprays the cleaning liquid to the preset position of the substrate and/or the sealing member.

7. The electroplating device according to claim 1, wherein during cleaning of the sealing member, a horizontal component of the spraying direction forms an acute included angle with the tangential direction of the rotation direction at the preset position on the horizontal plane when the nozzle sprays the cleaning liquid to the preset position of the substrate and/or the sealing member.

8. The electroplating device according to claim 1, wherein during cleaning of the sealing member, the nozzle is configured to spray the cleaning liquid to a region between the center of the substrate and the sealing member.

9. The electroplating device according to claim 1, wherein the nozzle is a linear nozzle or a fan-shaped nozzle.

10. A cleaning method applicable to the electroplating device according to any one of claims 1 to 9, comprising:

Step S10: lifting or lowering the substrate holder to a preset height above the nozzle and rotating the substrate holder at a preset rotating speed;

Step S20: enabling the nozzle to spray a first cleaning liquid to a preset position of the substrate and/or the sealing member at a preset flow rate, wherein the spraying direction has a component aligned with the tangential direction of the rotation direction

of the substrate holder at the preset position.

11. The cleaning method according to claim 10, wherein a dummy wafer is supported on the holder main body as the carried substrate during cleaning of the sealing member.

12. The cleaning method according to claim 11, wherein the cleaning method further comprises:

Step S30: switching from the first cleaning liquid to a second cleaning liquid to perform cleaning on the sealing member, wherein the first cleaning liquid is an acidic cleaning liquid, and the second cleaning liquid is pure water.