

ELECTROPLATING APPARATUS AND CLEANING METHOD

FIELD OF THE INVENTION

The present application relates to the field of semiconductor equipment, and more particularly, to an electroplating apparatus and a cleaning method.

BACKGROUND

A 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 during chip manufacturing.

In a conventional electroplating apparatus, a substrate holder includes conductive contact pins and a sealing member that are in contact with the substrate. The conductive contact pins should uniformly contact a seed layer on the front surface of the substrate, and meanwhile, the conductive contact pins must not be in direct contact with the electroplating solution. Therefore, the sealing member is required to isolate the conductive contact pins such that the electroplating solution cannot reach an edge of the front surface of the substrate; otherwise, metal will be plated 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 electroplating, residues such as residual electroplating solution and even photoresist often remain on the conductive contact pins and the sealing member. Such residues affect the manufacturing process of the substrate, such as causing uneven electric field distribution on the substrate, failure of substrate sealing, and wafer pick-up failure during transfer of the substrate by a robot after electroplating.

The document with patent application number 201911077619.1 provides an electroplating apparatus and a cleaning method, in which the middle section of a cleaning pipe in contact with the electroplating solution is arranged in an electroplating solution storage tank, so as to heat the middle section of the cleaning pipe by using the electroplating solution at a preset temperature to obtain heated cleaning liquid, and then the cleaning liquid is heated by using the electroplating solution at the preset temperature for spray cleaning of the substrate holder to remove residues.

SUMMARY

In view of the above technical problems, the object of the present application is to improve the cleaning effect of a substrate holder of an electroplating apparatus.

To achieve the above object, the present application provides an electroplating apparatus and a cleaning method.

In some embodiments, the electroplating apparatus described above comprises: a substrate holder including a holder main body, a conductive contact, and a sealing member, wherein the bottom portion of the holder main body extends radially inward to form a substrate support portion, the sealing member is disposed on the surface of the substrate support portion and protrudes upward at the end of the substrate support portion to form a sealing lip, and the sealing member and/or the holder main body are provided with a groove on the radially outward side of the sealing lip for accommodating the conductive contact; a cleaning system configured to inject cleaning liquid into the groove to immerse and clean the conductive contact; and a control system configured to control the substrate holder and the cleaning system to periodically perform immersion cleaning and spin-drying treatments on the conductive contact.

In some embodiments, the cleaning method described above comprises:

Step S01: lifting or lowering the unloaded substrate holder to a preset height such that the substrate holder is higher than a nozzle of the cleaning system;

Step S02: rotating the substrate holder at a first rotational speed, spraying cleaning liquid into the groove by the nozzle at a preset flow rate for a first preset duration to immerse and clean the conductive contact, and the nozzle stopping spraying the cleaning liquid before the volume of the cleaning liquid injected into the groove exceeds the maximum water storage capacity of the groove;

Step S03: rotating the substrate holder at a second rotational speed for a second preset duration, the second rotational speed being greater than the first rotational speed, so as to spin-dry the cleaning liquid in the groove.

Compared with a conventional solution in which a nozzle is used to spray and clean the substrate holder, the present application periodically performs immersion cleaning and spin-drying treatments on the conductive contact, so that the cleaning liquid is in more sufficient contact with the conductive contact, residues on the surface of the conductive contact are more easily removed, and the cleaning effect of the substrate holder is thereby improved.

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 apparatus according to an embodiment of the present application;

FIG. 2a is a partial enlarged view of region a in FIG. 1 according to an embodiment of the present application;

FIG. 2b is a partial enlarged view of region a in FIG. 1 according to another embodiment of the present application;

FIG. 3 is a schematic view of an electroplating apparatus according to an embodiment of the present application;

FIG. 4 is a partial enlarged view of region b in FIG. 3;

FIG. 5 is a schematic view of the cleaning liquid in the groove shown in FIG. 2a in a state of maximum water storage capacity;

FIG. 6 is a flow chart of the steps 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. 2a, an electroplating apparatus 100 according to an embodiment of the present application is disclosed, and the electroplating apparatus 100 comprises a substrate holder 120, a cleaning system 130, and a control system 140.

The substrate holder 120 includes a holder main body 121, a conductive contact

122, and a sealing member 123. The bottom portion of the holder main body 121 extends radially inward to form a substrate support portion 1211. The sealing member 123 is disposed on the surface of the substrate support portion 1211 and protrudes upward at the end of the substrate support portion 1211 to form a sealing lip 1231. The sealing member 123 and/or the holder main body 121 are provided with a groove 1232 on the radially outward side of the sealing lip 1231 for accommodating the conductive contact 122. The cleaning system 130 is configured to inject cleaning liquid into the groove 1232 to immerse and clean the conductive contact 122. The control system 140 is configured to control the substrate holder 120 and the cleaning system 130 to periodically perform immersion cleaning and spin-drying treatments on the conductive contact 122. It should be noted that the holder main body 121 is generally adapted to the shape of a substrate 200; for example, if the substrate 200 is circular, the holder main body 121 is annular. Therefore, “radial” mentioned above may be understood as a direction from a certain position on the holder main body toward the center line of the holder main body. In addition, the end of the substrate support portion 1211 mentioned above refers to the end of the substrate support portion 1211 close to the center line of the holder main body 121.

Specifically, the substrate holder 120 further includes an inner pressure ring 126 and an outer pressure ring 127. The inner pressure ring 126 is locked on the inner circumferential surface 1212 of the holder main body 121, and the outer pressure ring 127 is locked on the outer circumferential surface 1213 of the holder main body 121. The sealing member 123 includes an inner end portion 1233, a sealing member main body 1234, and an outer end portion 1235. The outer end portion 1235 is fixed between the outer pressure ring 127 and the holder main body 121, and the inner end portion 1233 is fixed between the inner pressure ring 126 and the holder main body 121. The sealing member main body 1234 covers the upper surface, the inner circumferential surface, and the lower surface of the substrate support portion 1211. The sealing lip 1231 is provided on the upper surface of the sealing member main body 1234, and the sealing lip 1231 is higher than the upper surface of the sealing member main body 1234, such that the groove 1232 is formed between the upper surface of the sealing member main body 1234 on the radially outward side of the sealing lip 1231 and the inner pressure ring 126, i.e., the groove 1232 is located on the upper surface of the sealing member main body 1234. In addition, one end 1221 of the conductive contact

122 is fixed between the inner end portion 1233 of the sealing member 123 and the inner pressure ring 126, and the other end 1222 of the conductive contact 122 extends along the surface of the sealing member main body 1234 into the groove 1232.

As shown in FIG. 2b, in another embodiment of the present application, the substrate holder 120 includes an inner pressure ring 129 locked on the inner circumferential surface 1212 of the holder main body 121. The end of the substrate support portion 1211 protrudes upward, and a protruding portion 1214 is covered by the sealing member 123 to form the sealing lip 1231. The groove 1232 is formed between the upper surface of the substrate support portion 1211 on the radially outward side of the sealing lip 1231 and the inner pressure ring 129, and the upper surface of the substrate support portion 1211 on the radially outward side of the sealing lip 1231 is not covered by the sealing member 123, i.e., the groove 1232 is located on the upper surface of the substrate support portion 1211. In addition, one end 1221 of the conductive contact 122 is fixed between the substrate support portion 1211 and the inner pressure ring 126, and the other end 1222 of the conductive contact 122 extends along the surface of the substrate support portion 1211 into the groove 1232.

In practical application, when the substrate holder 120 is in an unloaded state, as shown in FIG. 1, FIG. 2a, and FIG. 2b, the end 1222 of the conductive contact 122 away from the inner pressure ring 126 has a rebound height greater than the rebound height of the sealing lip 1231; when the substrate holder 120 is in a state loaded with the substrate 200, as shown in FIG. 3 and FIG. 4, the substrate 200 is clamped between a pressing plate 128 and the substrate support portion 1211, and the end 1222 of the conductive contact 122 away from the inner pressure ring 126 is deformed under pressure of an edge of the substrate 200, so that the conductive contact 122 is in sufficient electrical contact with the substrate 200 until the edge of the substrate 200 is in sealing contact with the sealing lip 1231, thereby isolating the conductive contact 122 from the electroplating solution in a process chamber 110.

Preferably, the cleaning system 130 includes a nozzle 131 configured to spray the cleaning liquid into the groove 1232. During immersion cleaning, the control system 140 controls the substrate holder 120 to rotate at a first rotational speed, and the nozzle 131 sprays the cleaning liquid into the groove 1232 at a preset flow rate for a first preset duration, with the cleaning liquid injected into the groove 1232 not exceeding

the maximum water storage capacity of the groove 1232. During spin-drying treatment, the control system 140 controls the nozzle 131 to stop spraying the cleaning liquid, and the substrate holder 120 rotates at a second rotational speed for a second preset duration, with the second rotational speed greater than the first rotational speed, so as to spin-dry the cleaning liquid in the groove 1232. In addition, the cleaning system 130 further includes a cleaning liquid storage tank 132 connected to the nozzle 131 via a pipeline 133 for supplying the cleaning liquid to the nozzle 131.

Preferably, the nozzle 131 is configured to have an obliquely upward spraying direction, and the holder main body 121 is located above the nozzle 131 during immersion cleaning. In practical application, a holder bracket 124 (refer to FIG. 1) is arranged above the holder main body 121 for connecting the holder main body 121 to a driving device 125. If the nozzle 131 is configured to have an obliquely downward spraying direction, the holder main body 121 needs to be moved below the nozzle 131 during immersion cleaning, and the holder bracket 124 will block the spraying path of the nozzle 131, causing the cleaning liquid to be sprayed onto the surface of the holder bracket 124, reducing cleaning efficiency, and posing a risk of dripping the cleaning liquid into the process chamber 110 to contaminate the electroplating solution.

Specifically, with continued reference to FIG. 2a, during immersion cleaning, the nozzle 131 sprays the cleaning liquid onto the inner wall of the inner pressure ring 126 along the spraying path S, and the cleaning liquid flows from the inner wall of the inner pressure ring 126 along the conductive contact 122 into the groove 1232 until the other end 1222 of the conductive contact 122 is immersed in the cleaning liquid. It should be noted that due to the surface tension of the cleaning liquid, in some cases, the liquid surface in the groove 1232 is slightly higher than the top of the groove 1232, and the liquid can submerge the other end 1222 of the conductive contact 122.

Preferably, as shown in FIG. 3, the electroplating apparatus 100 further comprises the process chamber 110.

Specifically, the process chamber 110 includes an inner chamber 111, an overflow groove 112, and a protective cover 113. The inner chamber 111 is configured to store the electroplating solution and has an opening 1111, and the substrate holder 120 moves into or out of the inner chamber 111 through the opening 1111. The overflow

groove 112 is provided surrounding the outer periphery of the opening 1111 and configured to collect the electroplating solution overflowing from the inner chamber 111. The protective cover 113 is provided above and surrounding the overflow groove 112 and configured to block the cleaning liquid thrown out by the substrate holder 120 during spin-drying treatment, and the nozzle 131 is provided on the inner side wall 1131 of the protective cover 113.

Preferably, the inner side wall 1131 is provided with an annular collection groove 1132 configured to collect the cleaning liquid thrown out by the substrate holder 120 during spin-drying treatment, and the nozzle 131 is provided in the annular collection groove 1132. In this embodiment, the annular collection groove 1132 can collect not only the cleaning liquid thrown out by the substrate holder 120 during spin-drying treatment but also the cleaning liquid remaining on the nozzle 131, reducing the risk of contamination of the electroplating solution in the process chamber 110.

Preferably, at least two nozzles 131 are arranged on the inner side wall 1131 of the protective cover 113, and the at least two nozzles 131 described above are arranged at intervals on the same circumference. In this embodiment, increasing the number of nozzles 131 can increase the injection speed of the cleaning liquid into the groove 1232, thereby reducing the first preset duration for spraying the cleaning liquid into the groove 1232 and improving the cleaning efficiency of the apparatus.

Preferably, the first rotational speed is configured such that the substrate holder 120 does not throw out the cleaning liquid when the substrate holder 120 rotates at the first rotational speed and the nozzle 131 sprays the cleaning liquid into the groove 1232 at the preset flow rate for the first preset duration. The second rotational speed is configured such that the substrate holder 120 throws out the cleaning liquid when the substrate holder 120 rotates at the second rotational speed.

Preferably, the first rotational speed described above ranges from 100 r/min to 150 r/min, the first preset duration described above ranges from 3 s to 4 s, and the preset flow rate ranges from 150 ml/min to 200 ml/min; the second rotational speed ranges from 300 r/min to 400 r/min, and the second preset duration ranges from 4 s to 5 s.

Specifically, to prevent the excessive cleaning liquid injected into the groove 1232 from overflowing the groove 1232 and dripping into the inner chamber 111 to cause contamination of the electroplating solution, the first preset duration T_1 , the preset flow rate Q , and the maximum water storage capacity $V_{\max}$ should satisfy: $T_1 \times Q \leq V_{\max}$.

In addition, the groove 1232 has an annular structure, and the bottom surface of the groove 1232 is circular. When the volume of cleaning liquid injected into the groove 1232 approaches the maximum water storage capacity $V_{\max}$ of the groove 1232, as shown in FIG. 5, the cross-section of the cleaning liquid retained in the groove 1232 is approximately in the form of a triangle 1321. If a two-dimensional coordinate system is established with an upward direction along the center line of the substrate holder 120 as a Y-axis and a straight line 1322 radially passing through the inner bottom surface of the groove 1232 of the substrate holder 120 as an X-axis, the maximum water storage capacity $V_{\max}$ is approximately equal to the volume obtained by rotating the triangle 1321 around the Y-axis for one circle. In addition, assuming that the coordinates of the three vertices of the triangle 1321 are $(m, 0)$, $(n, 0)$, and (n, h) , then:

$$V_{\max} = (\pi n^2 \cdot h - \pi m^2 \cdot h) / 2 = \pi (n^2 - m^2) \cdot h / 2;$$

where m refers to the inner circle radius of the bottom surface of the groove;

n refers to the outer circle radius of the bottom surface of the groove;

h refers to the height of the conductive contact from the bottom surface of the groove.

If measured data are $m = 148$ mm, $n = 153$ mm, and $h = 5$ mm;

Substituting into the above formula gives $V_{\max} \approx 11.820$ ml.

Multiple tests are performed under the premise of satisfying $T_1 \times Q \leq V_{\max}$, and the optimal value of the first preset duration T_1 is 3.5 s, and the optimal value of the preset flow rate Q is 180 ml/min.

Further, tests are performed based on the preset flow rate $Q = 180$ ml/min, and it is found that the injection of cleaning liquid into the groove 1232 is most stable when

the first rotational speed is 150 r/min. If the first rotational speed is too high, the cleaning liquid is subjected to a relatively large centrifugal force, causing the cleaning liquid to be thrown out of the groove 1232; if the first rotational speed is too low, excessive cleaning liquid is injected into the same region of the groove 1232, causing the cleaning liquid to overflow the groove 1232.

In addition, tests are performed based on $V_{\max} \approx 11.820$ ml, and it is found that all the cleaning liquid in the groove 1232 can be thrown out when the second rotational speed is 400 r/min and the first preset duration T_1 is 4 s.

As shown in FIG. 6, a cleaning method according to an embodiment of the present application is disclosed, and the cleaning method is applicable to the electroplating apparatus 100 according to any of the above embodiments and comprises:

Step S01: lifting or lowering the unloaded substrate holder 120 to a preset height such that the substrate holder 120 is higher than the nozzle 131 of the cleaning system 130;

Step S02: rotating the substrate holder 120 at a first rotational speed, spraying cleaning liquid into the groove 1232 by the nozzle 131 at a preset flow rate for a first preset duration to immerse and clean the conductive contact 122, and the nozzle 131 stopping spraying the cleaning liquid before the volume of the cleaning liquid injected into the groove 1232 exceeds the maximum water storage capacity of the groove 1232;

Step S03: rotating the substrate holder 120 at a second rotational speed for a second preset duration, the second rotational speed being greater than the first rotational speed, so as to spin-dry the cleaning liquid in the groove 1232.

Wherein, the steps S02 and S03 are repeatedly performed at least once to complete the cleaning of the conductive contact.

In this embodiment, periodic immersion cleaning and spin-drying treatments are performed on the conductive contact 122, so that the cleaning liquid is in more sufficient contact with the conductive contact 122, residues on the surface of the conductive contact 122 are more easily removed, and the cleaning effect of the

substrate holder 120 is thereby improved.

It should be noted that the above embodiments can be freely combined as required. The above are merely preferred embodiments of the present invention. For those of ordinary skill in the art, several improvements and modifications can be made without departing from the principle of the present invention, and these improvements and modifications shall also be regarded as falling within the protection scope of the present invention.

What is claimed is:

1. An electroplating apparatus, comprising:

a substrate holder, including a holder main body, a conductive contact, and a sealing member, wherein the bottom portion of the holder main body extends radially inward to form a substrate support portion, the sealing member is disposed on the surface of the substrate support portion and protrudes upward at the end of the substrate support portion to form a sealing lip, and the sealing member and/or the holder main body are provided with a groove on the radially outward side of the sealing lip for accommodating the conductive contact;

a cleaning system, configured to inject cleaning liquid into the groove to immerse and clean the conductive contact;

a control system, configured to control the substrate holder and the cleaning system to periodically perform immersion cleaning and spin-drying treatments on the conductive contact.

2. The electroplating apparatus according to claim 1, wherein the cleaning system includes a nozzle configured to spray the cleaning liquid into the groove; during the immersion cleaning, the control system controls the substrate holder to rotate at a first rotational speed, and the nozzle sprays the cleaning liquid into the groove at a preset flow rate for a first preset duration, with the cleaning liquid injected into the groove not exceeding the maximum water storage capacity of the groove; during the spin-drying treatment, the control system controls the nozzle to stop spraying the cleaning liquid, and the substrate holder rotates at a second rotational speed for a second preset duration, with the second rotational speed greater than the first rotational speed, so as to spin-dry the cleaning liquid in the groove.

3. The electroplating apparatus according to claim 2, wherein the maximum water storage capacity $V_{\max} = (\pi n^2 \cdot h - \pi m^2 \cdot h) / 2$;

where m refers to the inner circle radius of the bottom surface of the groove;

n refers to the outer circle radius of the bottom surface of the groove;

h refers to the height of the conductive contact from the bottom surface of the groove.

4. The electroplating apparatus according to claim 2, wherein the nozzle is configured to have an obliquely upward spraying direction, and the holder main body is located above the nozzle during the immersion cleaning.

5. The electroplating apparatus according to claim 2, wherein the electroplating apparatus further comprises a process chamber, the process chamber including:

an inner chamber, configured to store electroplating solution, the inner chamber having an opening, and the substrate holder moving into or out of the inner chamber through the opening;

an overflow groove, provided surrounding the outer periphery of the opening, and configured to collect the electroplating solution overflowing from the inner chamber;

a protective cover, provided above and surrounding the overflow groove, and configured to block the cleaning liquid thrown out by the substrate holder during the spin-drying treatment, wherein the nozzle is provided on the inner side wall of the protective cover.

6. The electroplating apparatus according to claim 5, wherein the inner side wall is provided with an annular collection groove configured to collect the cleaning liquid thrown out by the substrate holder during the spin-drying treatment, and the nozzle is provided in the annular collection groove.

7. The electroplating apparatus according to claim 5, wherein at least two nozzles are arranged on the inner side wall of the protective cover, and the at least two nozzles are arranged at intervals on the same circumference.

8. The electroplating apparatus according to claim 2, wherein the first rotational speed is configured such that the substrate holder does not throw out the cleaning liquid when the substrate holder rotates at the first rotational speed and the nozzle sprays the cleaning liquid into the groove at the preset flow rate for the first preset duration; and the second rotational speed is configured such that the substrate holder throws out the

cleaning liquid when the substrate holder rotates at the second rotational speed.

9. The electroplating apparatus according to claim 8, wherein the first rotational speed ranges from 100 r/min to 150 r/min, the first preset duration ranges from 3 s to 4 s, and the preset flow rate ranges from 150 ml/min to 200 ml/min; the second rotational speed ranges from 300 r/min to 400 r/min, and the second preset duration ranges from 4 s to 5 s.

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

Step S01: lifting or lowering the unloaded substrate holder to a preset height such that the substrate holder is higher than the nozzle of the cleaning system;

Step S02: rotating the substrate holder at a first rotational speed, spraying cleaning liquid into the groove by the nozzle at a preset flow rate for a first preset duration to immerse and clean the conductive contact, the nozzle stopping spraying the cleaning liquid before the volume of the cleaning liquid injected into the groove exceeds the maximum water storage capacity of the groove;

Step S03: rotating the substrate holder at a second rotational speed for a second preset duration, the second rotational speed being greater than the first rotational speed, so as to spin-dry the cleaning liquid in the groove;

wherein the Steps S02 and S03 are repeatedly performed at least once to complete the cleaning of the conductive contact.