# SUBSTRATE CLEANING DEVICE AND WET PROCESSING APPARATUS

## TECHNICAL FIELD

The present application relates to the field of semiconductor manufacturing technology, and in particular, to a substrate cleaning device and a wet processing apparatus.

## BACKGROUND

The basic process of photolithography typically includes three main steps: coating, exposure, and development. The purpose of the coating process is to form a thin, uniform, and defect-free photoresist layer on the surface of a substrate. Exposure involves transferring the pattern from a photomask onto the photoresist layer using an exposure lamp or other radiation sources. After exposure, device or circuit pattern is recorded on the photoresist layer in the form of exposed and unexposed regions. After development, the pattern of the photomask is fixed onto the photoresist layer. After the photolithography process, the photoresist layer can be used as a mask for an etching process or an ion implantation process. After etching or ion implantation, the photoresist on the substrate surface needs to be removed.

A common chemical solution used for wet cleaning to remove photoresist is Sulfuric Acid Hydrogen Peroxide Mixture (SPM). The cleaning steps are as follows: hydrogen peroxide is injected into a sulfuric acid solution. The hydrogen peroxide and sulfuric acid undergo an exothermic reaction, producing a high-temperature SPM solution. This SPM solution is sprayed onto the photoresist surface. The SPM solution reacts with the photoresist to remove the photoresist. Subsequently, the substrate surface is rinsed with deionized water, and finally, the substrate surface is dried with nitrogen. Latest research results show that heating sulfuric acid to a high temperature (e.g., above 180 °C) is beneficial for removing photoresist after high-dose ion implantation.

Therefore, it is necessary to provide a substrate cleaning device and a wet processing apparatus to solve the problem of how to heat sulfuric acid to a high temperature.

## SUMMARY

The purpose of the present invention is to solve the problem in the prior art of how to heat sulfuric acid to a high temperature.

To solve the above problem, an embodiment of the present invention provides a substrate cleaning device, comprising:

a nozzle;

a swing arm, wherein the nozzle is disposed at one end of the swing arm, a first fluid tube is disposed in the inner cavity of the swing arm, the first fluid tube is in communication with the nozzle for supplying a first fluid to the nozzle, the outer surface of the tube wall of the first fluid tube is covered with a heating film layer, and the heating film layer is used to transfer heat to the first fluid through the tube wall of the fluid tube, so that the temperature of the first fluid reaches the target temperature.

An embodiment of the present invention provides a wet processing apparatus, comprising:

a chamber;

a substrate support device, disposed inside the chamber, for supporting a substrate; and

the above-mentioned substrate cleaning device, wherein the nozzle of the substrate cleaning device is used for supplying a fluid to the substrate.

The substrate cleaning device provided in the present application disposes the first fluid tube in the inner cavity of the swing arm, and covers the outer surface of the tube wall of the first fluid tube with the heating film layer for heating the first fluid inside

the first fluid tube, enabling the first fluid to be heated to a high temperature to meet process requirements.

Other features and corresponding beneficial effects of the present invention will be described in the latter part of the specification, and it should be understood that at least some of the beneficial effects will become apparent from the description in the specification of the present invention.

## 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 cross-sectional view of the substrate cleaning device according to Embodiment 1 of the present application, viewed from a front perspective;

FIG. 2 is a cross-sectional view of the first fluid tube according to Embodiment 1 of the present application;

FIG. 3 is a cross-sectional view of the substrate cleaning device according to Embodiment 1 of the present application, viewed from a top perspective;

FIG. 4 is a partial cross-sectional view of the first fluid tube according to Embodiment 1 of the present application, viewed from a front perspective;

FIG. 5 is a schematic view of the first fluid tube according to Embodiment 2 of the present application;

FIG. 6 is a cross-sectional view of the substrate cleaning device according to Embodiment 2 of the present application; and

FIG. 7 is a schematic view of the wet processing apparatus according to Embodiment 3 of the present application.

## PREFERRED EMBODIMENTS OF THE APPLICATION

The embodiments of the present invention will be described using specific examples. Those skilled in the art can readily understand other advantages and effects of the present invention from the content disclosed in this specification. Although the description of the present invention will be introduced in conjunction with preferred embodiments, this does not mean that the features of the present invention are limited to these embodiments. On the contrary, the purpose of introducing the present invention in conjunction with embodiments is to cover other options or modifications that may be derived based on the claims of the present invention. To provide a deep understanding of the present invention, the following description will include many specific details. The present invention can also be implemented without following these details. Furthermore, to avoid confusion or obscuring the focus of the present invention, some specific details will be omitted in the description. It should be noted that, provided that no conflict arises, the embodiments in the present invention and the features of the embodiments may be combined with each other.

It should be noted that in this specification, similar reference numerals and letters indicate similar items in the following accompanying drawings. Therefore, once an item is defined in one accompanying drawing, further definition and explanation thereof are not required in subsequent accompanying drawings.

The technical solutions of the present invention will be clearly and completely described below with reference to the accompanying drawings. Obviously, the described embodiments are some, but not all, of the embodiments of the present invention. Based on the embodiments in the present invention, all other embodiments obtained by those of ordinary skill in the art without making creative efforts fall within the protection scope of the present invention.

In the description of the present invention, it should be noted that the terms "central," "upper," "lower," "left," "right," "vertical," "horizontal," "inner," "outer," etc., indicate orientations or positional relationships based on the orientations or positional relationships shown in the accompanying drawings. These terms are only for the convenience of describing the present invention and simplifying the description, and do not indicate or imply that the referred device or element must have a specific orientation, be constructed and operate in a specific orientation, and therefore cannot be understood as limiting the present invention. Furthermore, the terms "first,"

"second," and "third" are used for descriptive purposes only and cannot be understood as indicating or implying relative importance.

In the description of the present invention, it should be noted that, unless otherwise explicitly specified and defined, the terms "mount," "interconnect," and "connect" should be understood in a broad sense. 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 or an indirect connection through an intermediate medium, and the connection can be an internal communication between two elements. For those of ordinary skill in the art, the specific meanings of the terms described above in the present invention can be understood based on specific situations.

To further clarify the purpose, technical solutions, and advantages of the present invention, the embodiments of the present invention will be described in further detail below with reference to the accompanying drawings.

Embodiment 1

FIG. 1 shows a cross-sectional view of the substrate cleaning device according to Embodiment 1 of the present application, viewed from a front perspective; FIG. 2 shows a cross-sectional view of the first fluid tube according to Embodiment 1 of the present application.

As shown in FIG. 1 and FIG. 2, a substrate cleaning device 1 provided by the present application comprises a nozzle 100 and a swing arm 200. The nozzle 100 is disposed at one end of the swing arm 200. A first fluid tube 210 is disposed in the inner cavity of the swing arm 200. The first fluid tube 210 is in communication with the nozzle 100 for supplying a first fluid to the nozzle. The outer surface of the tube wall of the first fluid tube 210 is covered with a heating film layer 220. Specifically, the heating film layer 220 has a silver electrode 221 for electrical connection with a wire. One end of the wire is connected to the silver electrode 221, and the other end of the wire is connected to a power source, so that the heating film layer 220 is energized to generate heat. After being energized, the heating film layer 220 can transfer heat to the first fluid through the tube wall of the fluid tube, so that the temperature of the first

fluid flowing from the first fluid tube 210 to the nozzle 100 reaches the target temperature, for example, an ultra-high temperature above 190 °C, to meet process requirements. In this embodiment, the heating film layer 220 is made of a nanomaterial, and the heating film layer 220 is plated on the outer surface of the tube wall of the first fluid tube 210 using a coating process. The nozzle 100 and the first fluid tube 210 are directly connected by welding. Both the nozzle 100 and the first fluid tube 210 are made of high-purity quartz material with high-temperature resistance, which can withstand ultra-high temperatures of 200 °C. The first fluid may be sulfuric acid ($H_2SO_4$).

Furthermore, the present application integrates the heating film layer 220 into the inner cavity of the swing arm 200, which can reduce heat loss of the heating film layer 220.

In some embodiments, as shown in FIG. 1, the first fluid tube 210 includes a straight tube. As shown in FIG. 2, the cross-section of the first fluid tube 210 is annular.

FIG. 3 shows a cross-sectional view of the substrate cleaning device according to Embodiment 1 of the present application, viewed from a top perspective; FIG. 4 shows a partial cross-sectional view of the first fluid tube according to Embodiment 1 of the present application, viewed from a front perspective.

In some embodiments, as shown in FIGS. 1, 3, and 4, the first fluid tube 210 has a first end wall 2101 and a second end wall 2102 opposed to each other. An inlet 2103 of the first fluid tube 210 is provided on the first end wall 2101, and an outlet 2104 of the first fluid tube 210 is provided on the second end wall 2102. In the height direction of the substrate cleaning device, the outlet 2104 is higher than the inlet 2103. In this embodiment, the outlet 2104 is designed at a higher position to allow the first fluid within the first fluid tube 210 to flow out relatively slowly, ensuring that the first fluid is heated more thoroughly. As shown in FIGS. 3 and 4, the substrate cleaning device further comprises a flow blocking member 211. The flow blocking member 211 is disposed inside the first fluid tube 210 and near the inlet 2103 of the first fluid tube 210. Specifically, the flow blocking member 211 includes a connecting rod 2111 and a stop block 2112. A first end of the connecting rod 2111 is disposed on the first end wall 2101, and a second end of the connecting rod 2111 extends towards the second

end wall 2102 and is connected to the stop block 2112. In the extension direction of the connecting rod 2111, the stop block 2112 is located directly in front of the inlet 2103 of the first fluid tube 210, for dispersing the first fluid entering through the inlet 2103. The dashed arrows in FIGS. 3 and 4 indicate the dispersion path of the first fluid defined by the stop block 2112, which is beneficial for the first fluid to be fully heated.

In some embodiments, as shown in FIG. 3, the swing arm 200 further includes a mounting member for mounting the first fluid tube 210 in the inner cavity of the swing arm 200. In this embodiment, the mounting member includes support blocks 231 and fixing blocks 232. Two support blocks 231 are provided for supporting the two ends of the first fluid tube 210, respectively. Two fixing blocks 232 are provided, and the two fixing blocks 232 are fixed to the two ends of the swing arm 200 and abut against the two support blocks 231, respectively, thereby fixing and limiting the position of the first fluid tube 210.

With reference to FIG. 1 again, in some embodiments, the substrate cleaning device 1 further comprises a first temperature sensor 310 and a second temperature sensor 320. The first temperature sensor 310 is disposed on the first fluid tube 210 and near the inlet 2103 for detecting the temperature of the first fluid entering the first fluid tube 210. The second temperature sensor 320 is disposed on the first fluid tube 210 and near the outlet 2104 for detecting the temperature of the first fluid flowing out of the first fluid tube 210. The type of the first temperature sensor 310 and the second temperature sensor 320 can be a resistance temperature detector sensor, a thermistor sensor, a thermocouple sensor, or the like. In this embodiment, by providing the first temperature sensor 310, based on the target temperature T of the first fluid flowing out of the first fluid tube 210 and the temperature T1 of the first fluid detected by the first temperature sensor 310, a temperature difference $\Delta T = T - T1$ is obtained. When the flow rate of the first fluid within the first fluid tube 210 is constant, based on the difference between the target temperature T and the temperature T1, i.e., $\Delta T = T - T1$, a corresponding heating power P is determined so that the heating film layer 220 (the heating film layer 220 in FIG. 2) heats the first fluid flowing through the interior of the first fluid tube 210. By providing the second temperature sensor 320 to detect the temperature T2 of the first fluid flowing out of the first fluid tube 210, it can be determined whether the temperature T2 has reached the target temperature T. After the

process is complete, the power supply of the heating film layer 220 is turned off. After the process is completed, the residual temperature of the first fluid tube 210 and the heating film layer 220 is excessively high. A gas purging pipeline 400, as shown in FIG. 3, can be used to purge the inner cavity of the swing arm 200 with an inert gas or nitrogen to cool down the parts inside the inner cavity of the swing arm 200, such as the first fluid tube 210 and the heating film layer 220, reducing the impact of prolonged high temperature on the lifespan of related parts. Additionally, purging an inert gas or nitrogen can remove acidic gas from the inner cavity of the swing arm 200.

In some embodiments, as shown in FIG. 3, the swing arm 200 of the substrate cleaning device 1 includes a housing 240, a first thermal insulation member 251, a second thermal insulation member 252, and an anti-corrosion layer 253. The inner cavity of the swing arm 200 is located inside the housing 240. The housing 240 is made of stainless steel material. The first thermal insulation member 251 is disposed on the inner peripheral surface of the housing 240, providing insulation and thermal insulation. The material used for the first thermal insulation member 251 is, for example, mica. The second thermal insulation member 252 is disposed between the first thermal insulation member 251 and the housing 240, further providing thermal insulation. The thermal insulation materials of the first thermal insulation member 251 and the second thermal insulation member 252 are different. The second thermal insulation member 252 is, for example, thermal insulation cotton. The anti-corrosion layer 253 is wrapped around the outer peripheral surface of the housing 240 to prevent acidic gas in the process environment from corroding the housing 240. The anti-corrosion layer 253 is a Teflon coating.

As shown in FIG. 1, the substrate cleaning device 1 further comprises a column 260. The column 260 is disposed at the other end of the swing arm 200 for driving the swing arm 200 to move up and down and rotate. A pipeline channel 261 is disposed inside the column 260 for allowing pipelines or wires to pass through, such as the wire for the heating film layer 220 and the pipeline connected to the first fluid tube 210, and the pipeline channel 261 also serves as the outlet for the inert gas purged by the gas purging pipeline 400.

As shown in FIG. 1, in some embodiments, the substrate cleaning device 1 further comprises a second fluid tube 500, an exhaust passage 600, and a thermal insulation

layer 120. The second fluid tube 500 is used for supplying a second fluid to the nozzle 100. The nozzle 100 includes a confluence portion 110. The confluence portion 110 is in communication with the first fluid tube 210 and the second fluid tube 500, respectively, so that the first fluid and the second fluid are mixed in the confluence portion 110 and then flow out of the nozzle 100. As shown in FIG. 1, the thermal insulation layer 120 is disposed on the outer side of the nozzle 100 to provide thermal insulation. The thermal insulation layer 120 can be made of Polytetrafluoroethylene (PTFE) material. The confluence portion 110 is also in communication with the exhaust passage 600. The exhaust passage 600 is used for discharging bubbles generated during the mixing of the first fluid and the second fluid. The second fluid can be hydrogen peroxide ($H_2O_2$). When hydrogen peroxide mixes with ultra-high temperature sulfuric acid above 190 °C in the confluence portion 110, the mixture is heated to a temperature higher than 190 °C, e.g., above 200 °C, which is beneficial for removing photoresist after high-dose ion implantation and can significantly improve photoresist removal efficiency, thereby also reducing the usage amount of the mixed solution of sulfuric acid and hydrogen peroxide (SPM solution).

Embodiment 2

FIG. 5 shows a schematic view of the first fluid tube according to Embodiment 2 of the present application; FIG. 6 shows a cross-sectional view of the substrate cleaning device according to Embodiment 2 of the present application.

As shown in FIG. 5 and FIG. 6, compared with Embodiment 1, Embodiment 2 is different in that: first, the first fluid tube 210 includes a spiral tube; second, the first temperature sensor 310 is disposed on a supply pipeline in communication with the first fluid tube 210.

In this embodiment, the first fluid tube 210 is designed as a spiral shape, and compared with the straight tube in Embodiment 1, the spiral tube increases the heating area of the first fluid per unit volume, which can improve heat exchange efficiency.

It should be noted that in FIG. 1 and FIG. 6, identical elements or elements having identical functions are denoted by identical reference numerals, and repeated description is omitted.

Embodiment 3

FIG. 7 shows a schematic view of the wet processing apparatus according to Embodiment 1 of the present application.

As shown in FIG. 7, the present application provides a wet processing apparatus, comprising a chamber 2, a substrate support device 3, and the above-mentioned substrate cleaning device 1. The substrate support device 3 is disposed inside the chamber 2 for supporting a substrate 1000. The nozzle 100 of the substrate cleaning device 1 is used for supplying a fluid to the substrate 1000. This fluid is a mixed fluid formed by mixing the first fluid and the second fluid, for example, an SPM solution.

Finally, it should be noted that the embodiments described above are merely used to illustrate the technical solutions of the present invention, and not to limit the technical solutions. Although the present invention has been described in detail with reference to the foregoing embodiments, those of ordinary skill in the art should understand that the technical solutions described in the foregoing embodiments can still be modified, or equivalent substitutions can be made to some or all of the technical features therein. These modifications or substitutions do not cause the essence of the corresponding technical solutions to depart from the scope of the technical solutions of the embodiments of the present invention.

Claims:

1. A substrate cleaning device, comprising:

a nozzle;

a swing arm, wherein the nozzle is disposed at one end of the swing arm, a first fluid tube is disposed in the inner cavity of the swing arm, the first fluid tube is in communication with the nozzle for supplying a first fluid to the nozzle, the outer surface of the tube wall of the first fluid tube is covered with a heating film layer, and the heating film layer is used to transfer heat to the first fluid through the tube wall of the first fluid tube, so that the temperature of the first fluid reaches the target temperature.

2. The substrate cleaning device according to claim 1, wherein the first fluid tube includes a straight tube.

3. The substrate cleaning device according to claim 1, wherein the first fluid tube includes a spiral tube.

4. The substrate cleaning device according to claim 1 or 2, wherein the substrate cleaning device further comprises: a flow blocking member, disposed inside the first fluid tube and near the inlet of the first fluid tube, for dispersing the first fluid entering through the inlet.

5. The substrate cleaning device according to claim 4, wherein the first fluid tube has a first end wall and a second end wall opposed to each other, the inlet of the first fluid tube is provided on the first end wall, and the outlet of the first fluid tube is provided on the second end wall; the flow blocking member includes a connecting rod and a stop block, a first end of the connecting rod is disposed on the first end wall, a second end of the connecting rod extends towards the second end wall and is connected to the stop block, and in the extension direction of the connecting rod, the stop block is located directly in front of the inlet of the first fluid tube.

6. The substrate cleaning device according to claim 1, wherein the substrate cleaning device further comprises: a gas purging pipeline, in communication with the

inner cavity of the swing arm, for purging the inner cavity of the swing arm with an inert gas or nitrogen.

7. The substrate cleaning device according to claim 1, wherein the substrate cleaning device further comprises: a first temperature sensor, for detecting the temperature of the first fluid entering the first fluid tube.

8. The substrate cleaning device according to claim 1, wherein the substrate cleaning device further comprises: a second temperature sensor, for detecting the temperature of the first fluid flowing out of the first fluid tube.

9. The substrate cleaning device according to claim 1, wherein the swing arm includes: a housing, the inner cavity being located inside the housing; a first thermal insulation member, disposed on the inner peripheral surface of the housing.

10. The substrate cleaning device according to claim 9, wherein the swing arm further includes a second thermal insulation member disposed between the first thermal insulation member and the housing, and the thermal insulation material of the first thermal insulation member and the thermal insulation material of the second thermal insulation member are different.

11. The substrate cleaning device according to claim 9, wherein the housing is made of a stainless steel material.

12. The substrate cleaning device according to claim 9, wherein the swing arm further includes: an anti-corrosion layer, wrapped around the outer peripheral surface of the housing.

13. The substrate cleaning device according to claim 12, wherein the anti-corrosion layer is a Teflon coating.

14. The substrate cleaning device according to claim 1, wherein the substrate cleaning device further comprises: a thermal insulation layer, disposed on the outer side of the nozzle.

15. The substrate cleaning device according to claim 1, wherein the substrate cleaning device further comprises: a second fluid tube, for supplying a second fluid to the nozzle; the nozzle includes a confluence portion, and the confluence portion is in communication with the first fluid tube and the second fluid tube, respectively, so that the first fluid and the second fluid are mixed in the confluence portion.

16. A wet processing apparatus, comprising:

a chamber;

a substrate support device, disposed inside the chamber, for supporting a substrate; and

the substrate cleaning device according to any one of claims 1 to 15, wherein the nozzle of the substrate cleaning device is used for supplying a fluid to the substrate.