SUBSTRATE TREATMENT METHOD AND SUBSTRATE TREATMENT APPARATUS

FIELD OF THE INVENTION

The present invention belongs to the field of semiconductor technology and relates to a substrate treatment method and a substrate treatment apparatus.

BACKGROUND

In the entire substrate manufacturing process, wet cleaning/etching process is used to remove particles or defects on a wafer through cleaning or etching using high-purity chemicals. The single-wafer wet cleaning process is widely used in substrate manufacturing due to the good reproducibility, uniformity, and stability of the process. Currently, the single-wafer wet cleaning process mainly fixes a substrate on a substrate chuck. While the substrate chuck rotates, a chemical solution is sprayed onto the substrate surface through a nozzle to perform the wet cleaning/etching process.

The substrate manufacturing process has extremely strict requirements for defect control on the substrate surface, and defects must be controlled down to several tens to ten nanometers. The defect control in the single-wafer wet cleaning/etching process is closely related to the integrity of the liquid film coverage of the chemical solution. Complete liquid film coverage can ensure that the substrate surface does not adsorb particles in the chamber environment, and at the same time, avoid defects such as water mark caused by the reaction of bare silicon on the substrate surface with water vapor and oxygen in the air.

Low-flow chemical solutions, such as isopropyl alcohol (IPA) or nitrogen-atomized water (Nano Spray CO_2 DIW), are used in the wet cleaning process. Compared with chemical solutions such as hydrofluoric acid (HF) and standard cleaning solutions (SC1/SC2, a mixture of hydrochloric acid, hydrogen peroxide, and water), the chemical solutions, such as IPA or nitrogen-atomized water (Nano Spray CO_2 DIW), have much lower flow rates. When used in the wet cleaning process, the low-flow chemical solutions are more likely to cause incomplete liquid film coverage. Therefore, when HF is used in combination with IPA or nitrogen-atomized water (Nano

Spray CO_2 DIW), after the silicon oxide on the surface of the substrate treated with HF is etched, the bare silicon is prone to reacting with water vapor and oxygen in the chamber to form water mark in the IPA or nitrogen-atomized water (Nano Spray CO_2 DIW) step due to incomplete liquid film coverage.

Therefore, it is necessary to provide a substrate treatment method and a substrate treatment apparatus.

SUMMARY

In view of the above-mentioned shortcomings of the prior art, the object of the present invention is to provide a substrate treatment method and a substrate treatment apparatus, which are used to solve the problem of incomplete liquid film coverage of chemical solutions in the prior art.

To achieve the above object and other related objects, the present invention provides a substrate treatment method, comprising the following steps:

continuously rotating a substrate; a first nozzle continuously spraying water above the central region of the substrate;

during the substrate cleaning process, the first nozzle starting moving from a first central position in the central region of the substrate to a first edge position in the edge region of the substrate, and a second nozzle starting spraying a chemical solution onto the rotating substrate and moving from a second edge position in the edge region of the substrate to a second central position in the central region of the substrate;

the first nozzle and the second nozzle performing staggered reciprocating movement between the central region and the edge region of the substrate until the substrate cleaning process is completed;

after the substrate cleaning process is completed, the second nozzle stopping spraying the chemical solution, and the first nozzle continuing to spray water and returning to the central region of the substrate.

Optionally, before the second nozzle starts spraying the chemical solution, the

first nozzle sprays water at the center of the substrate until the surface of the substrate is completely covered by water. Optionally, after the substrate cleaning process is completed, the second nozzle moves away from the substrate.

Optionally, the second nozzle stops spraying the chemical solution while moving away from the substrate.

Optionally, the movement range of the second nozzle above the substrate is larger than the movement range of the first nozzle.

Optionally, the second central position is the rotation center of the substrate, and the first central position is different from the second central position.

Optionally, both the first central position and the second central position are the rotation center of the substrate.

Optionally, the flow rate of water sprayed by the first nozzle is higher than the flow rate of the chemical solution sprayed by the second nozzle.

Optionally, the chemical solution sprayed by the second nozzle is nitrogen-atomized water.

Optionally, during the substrate cleaning process, the time for the first nozzle and the second nozzle to complete a one-way movement between the central region and the edge region of the substrate is the same.

Optionally, during the substrate cleaning process, the second nozzle starts moving after the first nozzle moves for time t, and the time t is shorter than the time for the first nozzle to complete a one-way movement.

Optionally, during the substrate cleaning process, the first nozzle and the second nozzle start moving synchronously according to the respective paths of the first nozzle and the second nozzle.

Optionally, the surface of the substrate exhibits hydrophobicity.

To achieve the above object and other related objects, the present invention further

provides a substrate treatment apparatus, comprising:

a support device, for placing a substrate;

a drive portion, for driving the support device to rotate;

a first swing arm and a second swing arm;

a first nozzle and a second nozzle, respectively arranged at the ends of the first swing arm and the second swing arm;

an arm driving mechanism, for driving the first swing arm and the second swing arm to perform rotational movement, thereby driving the first nozzle and the second nozzle to perform rotational movement;

a first pipeline and a second pipeline respectively connected to the first nozzle and the second nozzle, the first pipeline and the second pipeline being respectively provided with an on-off valve;

a processor, connected to the drive portion, the arm driving mechanism, and the on-off valves;

a memory, coupled with the processor, the memory storing processor-executable instructions; when the instructions are executed by the processor, the processor executing the above-mentioned method.

As described above, the substrate treatment method and the substrate treatment apparatus of the present invention continuously spray water during the substrate treatment process, ensuring the integrity of the liquid film coverage on the substrate surface and avoiding the risk of water mark formation caused by bare silicon being exposed in the chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a schematic diagram of the internal structure of a chamber for substrate treatment according to an embodiment of the present invention.

FIG. 2 is a schematic diagram of the chamber in an idle state according to an embodiment of the present invention, that is, both swing arms are in the original positions.

FIG. 3 is a schematic diagram of the swing arm provided with a nozzle for spraying water moving to the center of a substrate first according to an embodiment of the present invention.

FIG. 4 is a schematic diagram of the swing arm provided with a nozzle for spraying water moving to the center of the substrate and the swing arm provided with a nozzle for spraying a chemical solution moving to the starting position according to an embodiment of the present invention.

FIG. 5 is a schematic diagram of the movement trajectories of the two swing arms according to an embodiment of the present invention.

FIG. 6 is a schematic diagram of the actions of the two nozzles according to an embodiment of the present invention.

PREFERRED EMBODIMENTS OF THE INVENTION

The embodiments of the present invention are described below through specific embodiments. Those skilled in the art can easily understand other advantages and effects of the present invention from the content disclosed in this specification. The present invention can also be implemented or applied through other different specific embodiments, and various modifications or changes can be made to the details in this specification based on different viewpoints and applications without departing from the spirit of the present invention.

When the embodiments of the present invention are described in detail, for the convenience of description, the cross-sectional views showing the device structure will be partially enlarged not according to the general proportion, and the schematic diagrams are only examples, which should not limit the protection scope of the present

invention herein. In addition, the three-dimensional spatial dimensions of length, width, and depth should be included in actual production.

For the convenience of description, spatial relationship terms such as "below," "under," "lower than," "beneath," "above," and "on" may be used here to describe the relationship between one element or feature and other elements or features shown in the accompanying drawings. It will be understood that these spatial relationship terms are intended to include orientations of a device in use or operation other than the orientation depicted in the accompanying drawings. In addition, when a layer is referred to as being "between" two layers, the layer may be the only layer between the two layers, or one or more intermediate layers may also exist. As used herein, "between" includes the two endpoint values.

In the context of the present application, the structure where a first feature is "above" a second feature may include embodiments where the first feature and the second feature are in direct contact, and may also include embodiments where another feature is formed between the first feature and the second feature, where the first feature and the second feature may not be in direct contact.

It should be noted that the diagrams provided in this embodiment only schematically illustrate the basic concept of the present invention, so the diagrams only show the components related to the present invention rather than being drawn according to the number, shape, and size of the components in actual implementation. The type, quantity, and proportion of each component in actual implementation can be changed arbitrarily, and the component layout type may also be more complex.

As shown in FIG. 1, this embodiment provides a substrate treatment apparatus, comprising a chamber 1, and a substrate support device 2, a liquid recovery device 4, and a liquid supply device 5 located inside the chamber 1.

The substrate support device 2 includes a drive portion 21 and a support portion 22 for horizontally placing a substrate W. Under the driving force of the drive portion 21, the support portion 22 can perform rotational movement. Thus, the support portion 22 can drive the substrate W to perform rotational movement.

The liquid supply device 5 includes a first swing arm 51, a second swing arm 52, and a first nozzle 501 and a second nozzle 502 respectively located at the ends of the first swing arm 51 and the second swing arm 52. The first nozzle 501 is used to spray water to cover the substrate surface, and the second nozzle 502 is used to spray a chemical solution to clean particles on the substrate. Both the first swing arm 51 and the second swing arm 52 are provided with an arm driving mechanism (not shown) for driving the swing arms to perform rotational movement, so that the swing arms drive the first nozzle 501 and the second nozzle 502 to perform rotational movement. FIG. 5 shows the movement trajectory R1 of the first nozzle 501 and the movement trajectory R2 of the second nozzle 502. The supply sources of the chemical solution and water provide water and the chemical solution to the first nozzle 501 and the second nozzle 502, respectively. The supply sources and the nozzles perform flow control and regulation through a first pipeline and a second pipeline respectively connected to the first nozzle 501 and the second nozzle 502, and on-off valves B, flow valves C, etc. arranged on the pipelines. Here, the two swing arms are used to control the movement of the two nozzles, respectively. The two nozzles can be set to different movement speeds, so the nozzle movement speed has a larger adjustment range and a wider application range.

The liquid recovery device 4 surrounds the support device 2 and can recover the liquid expelled from the substrate W after the liquid is supplied from the first nozzle 501 and the second nozzle 502 to the rotating substrate W.

In FIG. 2, the chamber 1 (as shown in FIG. 1) is in an idle state, and both the first swing arm 51 and the second swing arm 52 are in the original positions. Before substrate treatment, the substrate W is kept in a rotating state, and the substrate continues to rotate until the cleaning process of the substrate is completed.

When the substrate treatment starts, first, as shown in FIG. 3, the first swing arm 51 moves from the original position to above the central region of the substrate W first, and the second swing arm 52 waits at the original position. The central region refers to the region on the substrate W that includes the rotation center of the substrate W and extends outward by a certain distance with the rotation center point as the center, and the certain distance does not exceed one-third of the distance between the rotation center point of the substrate W and the edge region of the substrate W.

Next, as shown in FIG. 4 and FIG. 6(a), after the first swing arm 51 reaches above the central region of the substrate W, the first nozzle 501 starts spraying water at a certain flow rate (for example, 0.6 L/min) to cover the surface of the substrate W, and then the second swing arm 52 moves to above the edge region of the substrate W. The edge region refers to the region on the substrate W that extends inward by a certain distance from the outer edge of the substrate W, and the certain distance does not exceed one-third of the distance between the rotation center point of the substrate W and the edge region of the substrate W. To achieve a better liquid film coverage effect, the flow rate of water sprayed by the first nozzle 501 is relatively high, and is higher than the flow rate of the chemical solution sprayed by the second nozzle 502, so as to ensure that the substrate surface is always covered by water film during the process of cleaning particles on the substrate surface. Preferably, to achieve a better liquid film coverage effect of the substrate, the first nozzle 501 sprays water above the rotation center of the substrate W.

Next, as shown in FIG. 6(b), after the water sprayed by the first nozzle 501 completely covers the surface of the substrate W (generally, the spray time is set to 20 seconds, and the spray time can be adjusted according to the actual situation), the second nozzle 502 starts spraying the chemical solution at a low flow rate without stopping the spray of water by the first nozzle 501. Exemplarily, the chemical solution is nitrogen-atomized water with 0.1 L/min of water and 40 L/min of nitrogen, which is supplied through two pipelines connected to the second nozzle 502 for spray.

Next, as shown in FIG. 6(c), during the substrate cleaning process, the first nozzle 501 and the second nozzle 502 spray water and the chemical solution respectively while performing staggered back-and-forth movement between the central region and the edge region of the substrate W. Here, the spray positions of the first nozzle 501 in the central region and the edge region of the substrate W are a first central position and a first edge position, respectively, and the spray positions of the second nozzle 502 in the central region and the edge region of the substrate W are a second central position and a second edge position, respectively. Specifically, the second nozzle 502 sprays the chemical solution while moving from the edge region of the substrate W to the central region of the substrate W, and at the same time, the first nozzle 501 moves from the central region of the substrate W to the edge region of the substrate W without

stopping spraying water; then, when the first nozzle 501 continues to spray water and reaches above the edge region of the substrate W, or at approximately the same time, the second nozzle 502 continues to spray the chemical solution and also reaches the central region of the substrate W; then, the first nozzle 501 moves from above the edge region of the substrate W to above the central region of the substrate W, and at the same time, or at approximately the same time, the second nozzle 502 moves from above the central region of the substrate W to above the edge region of the substrate W; thus, the first nozzle 501 and the second nozzle 502 perform cyclic movement between the central region of the substrate W and the edge region of the substrate W. Here, the approximately same time can be understood as: when the first nozzle starts moving back and forth between the central region and the edge region of the substrate, the second nozzle starts moving from the edge region to the central region after the first nozzle moves for time t, and the time t is shorter than the movement time of the first nozzle from the central region to the edge region, that is, the second nozzle starts moving back and forth before the first nozzle reaches the edge region, and the first swing arm and the second swing arm do not interfere with each other. In addition, when the two nozzles perform staggered movement between the central region and the edge region, the time for the two nozzles to complete a one-way path is the same. This design can better control the spray of the chemical solution and water in the edge region and the central region of the substrate without affecting the respective effects, and avoid the situation that water and the chemical solution are sprayed in the same region on the substrate surface, which can otherwise result in the formation of excessively thick water film that affects the effect of the chemical solution on treating the substrate. That is, when the chemical solution is sprayed in the central region, water is sprayed in the edge region, and when water is sprayed in the central region, the chemical solution is sprayed in the edge region. During the substrate cleaning process, the first nozzle 501 and the second nozzle 502 continue to spray water and the chemical solution respectively without stopping. In one embodiment, the movement ranges of the first nozzle and the second nozzle are the same, both from the rotation center of the substrate to the edge region of the substrate, that is, both the first central position and the second central position are the rotation center of the substrate. Preferably, in another embodiment, to prevent liquid splashing, the movement range of the first nozzle is smaller than the movement range of the second nozzle, that is, the movement range of the second nozzle is larger than the movement range of the first nozzle. When the flow

rate of the first nozzle is higher than the flow rate of the second nozzle, liquid splashing tends to happen. Therefore, when the first nozzle reaches the edge region of the substrate, the spray position of the first nozzle in the edge region is closer to the rotation center of the substrate than the spray position of the second nozzle in the edge region, that is, the first edge position is closer to the rotation center of the substrate than the second edge position. In addition, to ensure a better substrate cleaning effect, the spray range of the second nozzle extends outward from the rotation center of the substrate, so that the entire surface of the substrate is fully cleaned. Wherein, the spray range of the second nozzle is the region between the rotation center of the substrate and the edge region of the substrate, and the spray range of the first nozzle extends from a position at a certain distance from the rotation center of the substrate and not interfering with the second nozzle to the edge region, that is, the first central position is different from the second central position; exemplarily, the first nozzle 501 sprays water while moving back and forth within the range of 10 mm and 100 mm from the rotation center of the substrate W, and the second nozzle 502 sprays the chemical solution while moving back and forth within the range from the rotation center of the substrate W to 137 mm from the rotation center of the substrate W; preferably, the spray ranges of the first nozzle and the second nozzle are both from the rotation center of the substrate to the edge region of the substrate, that is, the spray ranges of both nozzles include the rotation center of the substrate. Specifically, the second nozzle sprays the chemical solution from the rotation center of the substrate to the edge region of the substrate to ensure that the entire substrate surface is treated, and the first nozzle sprays water from the rotation center of the substrate to the edge region of the substrate to ensure that the entire substrate surface is completely covered by water film. In addition, the time for both the first nozzle and the second nozzle to complete a one-way path is 3 seconds, that is, the time for the first nozzle 501 to move from the central region of the substrate W to the edge region of the substrate W is 3 seconds, and the time for the second nozzle to move from the edge region of the substrate W to the central region of the substrate W is also 3 seconds. The time for a one-way path of the two nozzles is the same, and when one nozzle moves from the edge region to the central region, the other nozzle moves from the central region to the edge region, and the two nozzles perform staggered back-and-forth movement, which can better ensure that the liquid sprayed by one nozzle will not be pushed back by the liquid sprayed by the other nozzle, which can otherwise cause liquid splashing.

Finally, as shown in FIG. 6(d), after the substrate cleaning process is completed, the second nozzle 502 stops spraying the chemical solution. Then, the first nozzle 501 starts moving to above the central region of the substrate W without stopping spraying water, and at the same time, the second nozzle 502 returns to the original position, as shown in 6(e). The completion of substrate cleaning can be set based on different methods. Exemplarily, the completion of substrate cleaning can be set according to time. For example, if the time for the nozzles to complete a one-way path movement is 3 seconds, then 15 seconds is set as the completion of substrate cleaning. The completion of substrate cleaning can also be set by other methods, such as the number of one-way passes completed by the nozzles.

In addition, FIG. 1 is a schematic block diagram of a system for implementing one or more embodiments of the present specification or executing the method according to one or more embodiments of the present specification. The substrate treatment apparatus comprises a processor 3 and a memory 6. The memory 6 stores programs for controlling various processes executed in the substrate treatment apparatus. The processor 3 is coupled with the memory 6 and connected to components such as the drive portion 21, the arm driving mechanism, and the on-off valves B and flow valves C on the pipelines where the nozzles are located. The processor 3 controls the operation of these components by reading and executing the programs stored in the memory 6, thereby controlling the operation of the substrate treatment apparatus.

Before treating the substrate using the above method in the present invention, it is necessary to remove the oxide layer on the substrate surface. HF is used to remove the silicon oxide on the substrate surface, and then the above method is used to further treat the substrate. After removing the silicon oxide on the substrate surface, the silicon on the substrate surface is exposed, making the substrate surface hydrophobic. Therefore, even when water is involved throughout the substrate treatment method, no water mark will be formed.

In the present invention, during the substrate treatment process, water is continuously sprayed, which ensures the integrity of the liquid film coverage on the substrate surface and avoids the risk of water mark formation due to bare silicon being exposed in the chamber.

The above embodiments only exemplarily illustrate the principles and effects of the present invention, but are not used to limit the present invention. Anyone familiar with this technology can modify or change the above embodiments without departing from the spirit and scope of the present invention. Therefore, all equivalent modifications or changes completed by those with ordinary knowledge in the technical field without departing from the spirit and technical ideas disclosed by the present invention shall still be covered by the claims of the present invention.