

# **GAS PHASE ETCHING APPARATUS AND GAS PHASE ETCHING EQUIPMENT**

## **TECHNICAL FIELD**

The present disclosure relates to the field of a manufacturing process for an integrated circuit, in particular to a gas phase etching apparatus for removing silicon dioxide and a gas phase etching equipment for removing silicon dioxide applied in the manufacturing process for the integrated circuit.

## **BACKGROUND**

In the field of the manufacturing process for the integrated circuit, currently, the integrated circuit is usually manufactured with a silicon based material, and when silicon (or polycrystalline silicon) is placed in the air, a surface thereof will be naturally oxidized such that a dense layer of silicon dioxide ( $\text{SiO}_2$ ) is generated, as shown in Fig.1. In some process, a metal film is required to be in direct contact with a substrate made of the silicon based material. If there is a layer of  $\text{SiO}_2$  on the surface of the substrate, the resistivity will be increased, thereby adversely affecting the performance of the component. Thus, the layer of  $\text{SiO}_2$  needs to be removed before the process for forming the metal film.

In the prior art,  $\text{SiO}_2$  is usually removed by plasma etching, in the process of which  $\text{NF}_3$  and  $\text{NH}_3$  are used to generate a plasma to etch  $\text{SiO}_2$ . During the etching process,  $\text{NF}_3$  and  $\text{NH}_3$  react with  $\text{SiO}_2$  to generate  $(\text{NH}_4)_2\text{SiF}_6$ . Because  $(\text{NH}_4)_2\text{SiF}_6$  is in the solid state at a normal temperature, in order to discharge it out of a chamber, it is required to heat the substrate made of the silicon based material to  $120^\circ\text{C}$ , such that  $(\text{NH}_4)_2\text{SiF}_6$  is sublimated into  $\text{SiF}_4$ ,  $\text{H}_2\text{O}$  and  $\text{NH}_3$  to be discharged out of the chamber. Accordingly, the process for removing  $\text{SiO}_2$  with the plasma etching generally includes etching and annealing processes. After the annealing process, the surface of the substrate made of the silicon based material has a high temperature, and needs to be cooled down, resulting in a more complex process. Generally, the etching process and the annealing process may be performed in a same chamber, or in different chambers separately. Therefore, the current equipment for the process for removing  $\text{SiO}_2$  by the plasma etching mainly have two types: one has a process chamber structure for performing the plasma etching and in-situ annealing processes, that is, the etching process and the annealing process are performed in the same chamber, and then the silicon based material is cooled down in a separate cooling chamber, chambers of the equipment are correspondingly configured as an etching/annealing chamber plus a cooling chamber; the other has a flow in which the etching process and annealing process are

performed separately, that is, the etching process and annealing process are performed in different chambers, chambers of the equipment are correspondingly configured as an etching chamber plus an annealing chamber plus a cooling chamber.

The inventors found that the apparatus for removing silicon dioxide in the prior art needs multiple chambers, which is complex in process design, expensive in cost, and low in production capacity, and products in the process are in the solid state, which adversely affects the uniformity of etching and the cleaning efficiency at bottoms of small holes. Therefore, there is a need for developing an etching apparatus which removes silicon dioxide simply and efficiently.

The information disclosed in the background of the present disclosure is only intended to enhance understanding of a general background in the present disclosure, and should not be perceived as admitting or implying that the information constitutes the prior art known by a person skilled in the art.

## **SUMMARY**

In order to solve one of the problems in the prior art, the present invention discloses a gas phase etching apparatus and equipment applied in the manufacturing process for the integrated circuit for removing silicon dioxide. The gas phase etching apparatus and equipment are capable of respectively controlling a temperature of a reaction chamber and a temperature of a base supporting a workpiece being processed such that the workpiece being processed, from which silicon dioxide has been removed, can directly undergoes a subsequent process without a cooling process, obviating the need for integrating an annealing function in an etching chamber or providing an independent annealing chamber, and accordingly obviating the need for providing a separated cooling chamber, and therefore, the apparatus and equipment are simple in process design, inexpensive in cost, and high in production capacity.

According to an aspect of the present disclosure, there is provided a gas phase etching apparatus, including: a reaction chamber body, which defines a space for forming a reaction chamber; a base, which is arranged within the reaction chamber and configured to support a workpiece being processed; a gas intake element, which is connected to the reaction chamber body and configured to introduce an etchant into the interior of the reaction chamber; a pressure control component, which is connected to the reaction chamber body and configured to control a pressure in the reaction chamber; a first temperature controller, which is connected to the reaction chamber body and configured to control a temperature in the reaction chamber to a first temperature, the first temperature being a temperature at

which the reaction chamber cannot be corroded by the etchant; and a second temperature controller, which is connected to the base and configured to control a temperature of the base to a second temperature, the second temperature being a temperature at which the workpiece being processed supported by the base can satisfy a temperature requirement for directly performing a subsequent process.

Optionally, the first temperature controller controls the temperature in the reaction chamber to the first temperature through heat conduction, heat radiation and/or heat convection by controlling gas, liquid or solid media; and/or the second temperature controller controls the temperature of the base to the second temperature through heat conduction, heat radiation and/or heat convection by controlling gas, liquid or solid media.

Optionally, the first temperature is in a range of 50°C-90°C.

Optionally, the second temperature is in a range of 20°C-60°C.

Optionally, the pressure control component includes: a pressure controller configured to control the pressure in the reaction chamber to be in a range of 30Torr to 300Torr to improve an etch selectivity ratio.

Optionally, the gas phase etching apparatus further includes: a showerhead which is located in an upper region of the reaction chamber and connected to the gas intake element; the showerhead includes an upper uniform flow plate and a lower uniform flow plate, the etchant enters the reaction chamber via the upper uniform flow plate and the lower uniform flow plate of the showerhead, wherein a size of holes of the upper uniform flow plate is larger than a size of holes of the lower uniform flow plate.

Optionally, the gas phase etching apparatus further includes: a lining component which is placed in the inner space of the reaction chamber body and covers a sidewall of the reaction chamber body; and the lining component includes a first liner and a second liner, and a reaction by-product enters the pressure control component at least via a gap between the base and the first liner and a gap between the first liner and the second liner.

Optionally, the gap between the base and the first liner is smaller than the gap between the first liner and the second liner.

Optionally, the gas intake element introduces a dehydrated hydrogen fluoride gas and a dehydrated alcohol gas into the reaction chamber; the dehydrated hydrogen fluoride gas and the dehydrated alcohol gas are mixed to remove silicon dioxide on the workpiece being processed.

As another aspect, the present disclosure also provides a gas phase etching equipment, including: a transferring apparatus and the gas phase etching apparatus of any of above solutions of the present disclosure, the transferring apparatus is connected to the gas phase

etching apparatus such that the workpiece being processed is transferred between the transferring apparatus and the gas phase etching apparatus.

The apparatus for removing silicon dioxide on the workpiece being processed according to the present disclosure has the following advantages.

(1) In the gas phase etching apparatus and equipment provided by the present disclosure, the first temperature controller is provided for the reaction chamber, and the second temperature controller is provided for the base, such that temperatures of the reaction chamber and the base are controlled separately, thereby the temperature in the reaction chamber can be maintained at the first temperature at which an inner wall of the reaction chamber will not be etched, and the temperature of the base is controlled at the second temperature which is lower than the first temperature. In this way, after the etching process for removing surface oxides such as  $\text{SiO}_2$  is performed on the workpiece being processed supported by the base, the temperature of the workpiece being processed can satisfy a temperature requirement for directly performing a subsequent process, which obviates the need for cooling the workpiece being processed. In this way, it obviates the need for integrating an annealing function or an annealing chamber in the etching chamber, and accordingly, it obviates the need for providing a separate cooling chamber. Therefore, only the etching chamber is required to be provided for the gas phase etching apparatus and equipment, which is simple in structure, short in process routes, inexpensive in cost, and high in production capacity. Further, such a single chamber structure (only the etching chamber is required, and the annealing chamber and the cooling chamber are not required) facilitates integration with a subsequent process. That is, it is easier to integrate the single chamber structure with an apparatus required by the subsequent process on a same platform, such that the flexibility in use is better.

(2) Because the gas phase etching apparatus and equipment provided by the present disclosure are used in a gas phase etching process, that is, the oxide layer of  $\text{SiO}_2$  on the surface of the workpiece being processed is removed using the gas phase etching process, instead of the plasma etching process used in the prior art, when the oxide layer of  $\text{SiO}_2$  on the surface of the workpiece being processed is removed using the gas phase etching apparatus and equipment provided by the present disclosure, no reaction product in the solid state will be generated. In this way, the reaction product can be easily extracted from the chamber by a pump, such that the problem that the reaction product in the solid state blocks small holes in the prior art can be avoided, which not only is beneficial to removal of the layer of  $\text{SiO}_2$  at bottoms of small holes, but also improves the overall cleaning efficiency of the oxide layer of  $\text{SiO}_2$ .

(3) Further, when the oxide layer of  $\text{SiO}_2$  on the surface of the workpiece being processed is removed using the gas phase etching apparatus and equipment provided by the present disclosure, it needs to perform the process under a high pressure (for example, the pressure in the reaction chamber is in a range of 30Torr to 300Torr). In this way, the etchant is more easily absorbed on the surface of the workpiece being processed (such as a silicon wafer), which can speed up the rate of the reaction, and improve the etch selectivity ratio.

The apparatus according to the present disclosure has other characteristics and advantages, which are apparent from or described in detail in the drawings and the detail description of embodiments incorporated herein. The drawings and the detail description of embodiments are all used to explain specific principles of the present disclosure.

## **BRIEF DESCRIPTION OF DRAWINGS**

The above and other purposes, characteristics and advantages of the present disclosure will become more apparent by describing exemplary embodiments of the present disclosure in detail below in conjunction with the accompanying drawings, and in exemplary embodiments of the present disclosure, like reference numbers generally represent like components.

Fig.1 shows a schematic diagram of an integrated circuit device with a native oxide layer.

Fig.2 shows a structural schematic diagram of a gas phase etching apparatus according to an embodiment of the present disclosure.

Fig.3 shows a structural schematic diagram of a showerhead of a gas phase etching apparatus according to an embodiment of the present disclosure.

Figs.4a and 4b show structural schematic diagrams of a lining component of a gas phase etching apparatus according to an embodiment of the present disclosure, respectively.

Fig.5 shows a schematic diagram of a device after removing a native oxide layer using the method according to the present disclosure.

## **DETAIL DESCRIPTION OF EMBODIMENTS**

The present invention will be described in further detail below with reference to the accompanying drawings. The accompanying drawings illustrate exemplary implementations of the present invention, but it should be understood that the present invention may be implemented in various forms and should not be limited by the implementations stated herein. Rather, these implementations are provided in order to make the present invention more thorough and complete, and to deliver the scope of the present

invention in whole to those skilled in the art.

### Embodiment 1

Fig.2 shows a structural schematic diagram of a gas phase etching apparatus according to an embodiment of the present disclosure.

In the embodiment, the gas phase etching apparatus includes a reaction chamber body 201, which defines a space for forming a reaction chamber 203; a base 209, which is arranged at a bottom region within the reaction chamber 203 and configured to support a workpiece being processed, such as a wafer; a gas intake element 202, which is connected to the reaction chamber body 201 and through which a gaseous etchant is introduced into the interior of the reaction chamber 203; and a pressure control component, which is connected to the reaction chamber body 201 and configured to control the pressure in the reaction chamber 203. And the gas phase etching apparatus further includes a first temperature controller 208, which is connected to the reaction chamber body 201 and configured to control the temperature in the reaction chamber 203 to a first temperature at which an inner wall of the reaction chamber 203 will not be corroded by the etchant, that is, the first temperature is the temperature at which the reaction chamber 203 will not be corroded by the etchant; and a second temperature controller 207, which is connected to the base 209 and configured to control the temperature of the base 209 to a second temperature at which the workpiece being processed supported by the base 209 satisfies a temperature requirement for directly performing a subsequent process, that is, the second temperature is the temperature at which the workpiece being processed supported by the base 209 satisfies a temperature requirement for directly performing a subsequent process. The first temperature controller 208 controls the temperature in the reaction chamber 203 to the first temperature through heat conduction, heat radiation and/or heat convection by controlling gas, liquid or solid media; and/or the second temperature controller 207 controls the temperature of the base 209 to the second temperature through heat conduction, heat radiation and/or heat convection by controlling gas, liquid or solid media.

In the embodiment, by respectively controlling the temperature of the reaction chamber and the temperature of the base supporting a workpiece being processed, it is not required to cool the workpiece being processed after silicon dioxide is removed and before a subsequent process is performed, such that only an etching chamber is required to be provided for the gas phase etching apparatus, it obviates the need for integrating an annealing function in the etching chamber or additionally providing an annealing chamber, and accordingly it obviates the need for providing a separate cooling chamber, which solves

the problem in the prior art that the apparatus for removing silicon dioxide needs more than one chamber, and the apparatus and equipment are complex in process design, expensive in cost, and low in production capacity.

Next, a specific structure of a gas phase etching apparatus according to an embodiment of the present disclosure will be described in detail.

As shown in Fig.2, in one example, in the gas phase etching apparatus according to an embodiment of the present disclosure, the space defined by the reaction chamber body 201 forms the reaction chamber 203; and the base 209 configured to place a workpiece being processed is arranged at a bottom region within the reaction chamber 203. The gas intake element 202 may be connected to the reaction chamber body 201 and include multiple gas intake conduits, and a pneumatic valve 213 is provided on each of the gas intake conduits. In the case where the pneumatic valve 213 is open, the gaseous etchant may be mixed in the gas intake element 202 and enter into the reaction chamber 203 through the gas intake element 202.

Further, the gas phase etching apparatus may further include a first temperature controller 208 and a second temperature controller 207, and the first temperature controller 208 is connected to the reaction chamber body 201 and configured to control the temperature in the reaction chamber 203 to a first temperature at which an inner wall of the reaction chamber 203 will not be corroded by the etchant; the second temperature controller 207 is connected to the base 209 and configured to control the temperature of the base 209 to a second temperature at which the workpiece being processed supported by the base 209 can satisfy a temperature requirement for directly performing a subsequent process. Optionally, a temperature adjustment mechanism in the first temperature controller 208 may be a heat exchanger, and a temperature adjustment mechanism in the second temperature controller 207 may be a water chiller. However, a person skilled in the art should understand that the present disclosure is not limited thereto, any element for temperature control and adjustment and capable of controlling the temperature of the reaction chamber 203 and the temperature of the base 209 may be used.

In one example, the first temperature may be 50°C to 90°C and the second temperature may be 20°C to 60°C. Optionally, the first temperature is 70°C and the second temperature is 40°C. In this way, the temperature in the reaction chamber 203 is higher, which is beneficial to prevent the inner wall of the reaction chamber from being corroded by the etchant; and the temperature in the base 209 is lower, which causes the etchant to react with silicon dioxide on the workpiece being processed supported by the base 209 at the lower temperature, such that it obviates the need for providing an annealing chamber

and a cooling chamber, which saves the cost, shortens the process route, and improves the production capacity.

In one example, in the gas phase etching apparatus according to an embodiment of the present disclosure, a pressure control component may be connected to the reaction chamber body 201 for controlling the pressure in the reaction chamber 203.

In one example, as shown in Fig.2, the pressure control component may include: a pressure controller 206 for adjusting the pressure in the reaction chamber 203 to be in a range of 30Torr to 300Torr, improving an etch selectivity ratio for the gas phase etching process. Optionally, the pressure in the reaction chamber 203 may be 200Torr. In this way, the etchant is reacted at a high pressure by adjusting the pressure in the reaction chamber 203, thereby improving the etch selectivity ratio and the process efficiency.

In one example, the pressure control component may also include: a dry pump 205 and a molecular pump 204. The dry pump 205 is configured to adjust the humidity in the reaction chamber 203; the molecular pump 204 is configured to extract a reaction by-product from the reaction chamber 203 after the process ends. The pressure controller 206, the dry pump 205 and the molecular pump 204 can form a vacuum system. During the process, an adjustment of the pressure in the reaction chamber 203 is achieved by the pressure controller 206, the humidity in the reaction chamber 203 is controlled by the dry pump 205; after the process ends, the molecular pump 204 vacuumizes (such as extracts the reaction by-product), preparing for the subsequent transferring of the workpiece being processed.

Fig.3 shows a structural schematic diagram of a showerhead of a gas phase etching apparatus according to an embodiment of the present disclosure.

In one example, as shown in Figs.2 and 3, the gas phase etching apparatus according to an embodiment of the present disclosure further includes a showerhead 210. The showerhead 210 is located in an upper region of the reaction chamber 203 and connected to the gas intake element 202. The showerhead 210 may be a bi-layer structure, including an upper uniform flow plate 211 and a lower uniform flow plate 212. The etchant which enters the reaction chamber 203 from the gas intake element 202 enters the reaction chamber 203 via the upper uniform flow plate 211 and the lower uniform flow plate 212 of the showerhead 210. A size of holes of the upper uniform flow plate 211 is larger than that of the lower uniform flow plate 212.

For example, the gaseous etchant firstly enters the top of the upper uniform flow plate 211, and is blocked by the upper uniform flow plate 211 when flowing downward, thereby changing the flow direction. That is, the gaseous etchant is changed from flowing

downward along a vertical direction to flowing along a horizontal direction. Accordingly, a preliminary uniform gas flow of the gaseous etchant is achieved by the upper uniform flow plate 211, that is, the gaseous etchant at an edge region of the upper uniform flow plate 211 and the gaseous etchant at a center region of the upper uniform flow plate 211 reach a preliminary uniform gas flow by diffusing and flowing in the horizontal direction. Then, the gaseous etchant enters the top of the lower uniform flow plate 212 after passing through the upper uniform flow plate 211. After being blocked by the lower uniform flow plate 212, the gaseous etchant continues diffusing and flowing in the horizontal direction above the lower uniform flow plate 212 for further gas flow uniformity. Because the size of holes of the upper uniform flow plate 211 is larger than that of the lower uniform flow plate 212, the gaseous etchant can enter the showerhead 210 rapidly, and is slowly discharged from the showerhead 210, which is beneficial to full diffusion and uniform flow of the gaseous etchant in the showerhead 210, and ensures that the gaseous etchant passes the lower uniform flow plate 212 at a higher pressure, thereby satisfying the requirement of the high pressure process in the reaction chamber 203. The size of the holes of the lower uniform flow plate 212 may be less than 1mm, for example, the size of the holes of the lower uniform flow plate 212 may be 0.5mm.

Figs.4a and 4b show structural schematic diagrams of a lining component of a gas phase etching apparatus according to an embodiment of the present disclosure, respectively.

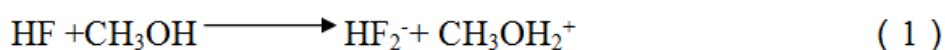
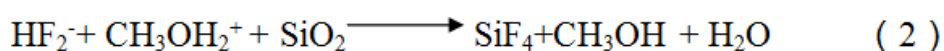
In one example, as shown in Figs.4a and 4b, the gas phase etching apparatus according to an embodiment of the present disclosure may further include: a lining component which is placed in the inner space of the reaction chamber body 201 (that is, in the reaction chamber 203) and covers the sidewall of the reaction chamber body 201. The lining component may include: a first liner 401 and a second liner 402. The reaction by-product successively passes a gap A between the base 209 and the first liner 401, a gap B between the first liner 401 and the second liner 402 and a small gap between the second liner 402 and the reaction chamber body 201, and then enters the molecular pump 204 of the pressure control component.

The lining component in the reaction chamber 203 can prevent the reaction chamber 203 from being corroded by the reactant gas to generate particles. As shown in Figs.4a and 4b, the gas passes the upper uniform flow plate 211 and the lower uniform flow plate 212 of the showerhead 210, passes the gap A between the base 209 and the first liner 401, the gap B between the first liner 401 and the second liner 402 and the small gap between the second liner 402 and the sidewall of the reaction chamber body 201, and then enters the vacuum system (the pressure control component), and is pumped out by the molecular pump 204

connected to the sidewall of the reaction chamber body 201. In order to satisfy the high pressure process, the gap A between the base 209 and the first liner 401 is required to be designed as being less than 2mm, the gap B between the first liner 401 and the second liner 402 is required to be designed as being less than 2mm, and A is less than B, for example, A=1.5mm, B=2mm, which causes fewer gaseous etchant to enter the region under the base 209, ensuring the utilization efficiency of the gaseous etchant.

In one example, the gas intake element 202 may introduce a dehydrated hydrogen fluoride gas and a dehydrated alcohol gas into the reaction chamber 203. The dehydrated hydrogen fluoride gas and the dehydrated alcohol gas are mixed to generate the etchant for removing silicon dioxide on the workpiece being processed.

In one example, the etchant may be generated by mixing the dehydrated HF gas with the dehydrated methyl alcohol (CH<sub>3</sub>OH) gas, for example. Specifically, with the methyl alcohol (CH<sub>3</sub>OH), reaction formulas for the gas phase etching apparatus according to an embodiment of the present disclosure may be represented as:



The gaseous etchants HF<sub>2</sub><sup>-</sup> and CH<sub>3</sub>OH<sub>2</sub><sup>+</sup> are generated by mixing the dehydrated HF gas with the dehydrated CH<sub>3</sub>OH gas, and then are mixed and reacted with SiO<sub>2</sub> to generate SiF<sub>4</sub>, CH<sub>3</sub>OH and H<sub>2</sub>O.

For example, in the process, a workpiece being processed is transferred from a transferring chamber to the reaction chamber 203, and the second temperature controller 207 controls the temperature of the base 209 for controlling the temperature of the workpiece being processed at 20°C-60°C, and the first temperature controller 208 is used for controlling the temperature of the components such as the reaction chamber 203 at 50°C-90°C. After the temperatures of the reaction chamber 203 and the workpiece being processed is stabilized, the base 209 is elevated to a position ready for the process, the CH<sub>3</sub>OH gas and the HF gas for the process (the gaseous etchants HF<sub>2</sub><sup>-</sup> and CH<sub>3</sub>OH<sub>2</sub><sup>+</sup> generated by mixing the dehydrated HF gas with the dehydrated CH<sub>3</sub>OH gas) are introduced for performing the process. During the process, the pressure controller 206 may control the pressure in the reaction chamber 203 to 30Torr~300Torr. Optionally, the pressure in the reaction chamber 203 is 200Torr, the temperature in the reaction chamber 203 is 70°C, and the temperature of the base 209 is 40°C.

In one example, the flow rate of the hydrogen fluoride gas is 100sccm-500sccm, and

the flow rate of the alcohol gas is 100sccm-1000sccm. Optionally, further, the flow rate of the hydrogen fluoride gas is 150sccm-225sccm, and the flow rate of the alcohol gas is 200sccm-450sccm.

In one example, a ratio of the flow rate of the hydrogen fluoride gas to the flow rate of the alcohol gas may be 0.8:1 to 1.2:1. Optionally, further, a ratio of the flow rate of the hydrogen fluoride gas to the flow rate of the alcohol gas may be 1:1.

In one example, the alcohol gas may be at least one of C<sub>1</sub>-C<sub>8</sub> monohydric alcohol gas. Optionally, further, the alcohol gas is at least one of methanol, ethanol and isopropyl alcohol.

Fig.5 shows a schematic diagram of a device after removing the native oxide layer of silicon dioxide using the gas phase etching apparatus according to the present disclosure. Comparing with the prior art, when the gas phase etching apparatus according to an embodiment of the present disclosure is used to remove the native oxide layer of SiO<sub>2</sub>, the reaction products are not in the solid state, and thus may be pumped out by a pump. In this way, the process obviates the need for performing the annealing process, thus, such an annealing process is omitted. Further because the reaction products are not in the solid state, the problem that the reaction products in the solid state block small holes in the prior art can be avoided, which is beneficial to clean the layer of SiO<sub>2</sub> at bottoms of small holes, thereby improving the cleaning efficiency of the native oxide layer of SiO<sub>2</sub>. Because the reaction temperature is low (generally  $\leq 40^{\circ}\text{C}$ ), it obviates the need for cooling the workpiece being processed after SiO<sub>2</sub> is removed, and a subsequent process may be directly performed, which obviates the need for integrating an annealing function or an annealing chamber in the gas phase etching apparatus, and obviates the need for providing a separate cooling chamber, causing the gas phase etching apparatus to be simple in structure, short in process routes, inexpensive in cost, and high in production capacity. Such a single chamber structure (it is only required to provide an etching chamber, without further providing an annealing chamber and a cooling chamber) is more beneficial to integrate with a subsequent process. That is, it is easier to integrate the single chamber structure with an apparatus required by the subsequent process on a same platform, such that the flexibility in use is better.

CH<sub>3</sub>OH has hygroscopicity, which further reduces residual H<sub>2</sub>O on the workpiece being processed. The higher process pressure is easier to cause the reactant gas to be absorbed on the surface of the workpiece being processed and react with SiO<sub>2</sub>, which enormously increases the cleaning rate and the cleaning uniformity of SiO<sub>2</sub> on the surface the workpiece being processed.

According to another aspect, the present disclosure also provides a gas phase etching equipment, including: a reaction apparatus and a transferring apparatus, and the reaction apparatus may be the gas phase etching apparatus of the above embodiments of the present disclosure, the transferring apparatus is connected to the reaction apparatus such that the workpiece being processed (such as a wafer) is transferred between the transferring apparatus and the reaction apparatus.

The gas phase etching apparatus and equipment according to the present disclosure have the following advantages:

(1) In the gas phase etching apparatus and equipment provided by the present disclosure, the first temperature controller is provided for the reaction chamber, and the second temperature controller is provided for the base, such that temperatures of the reaction chamber and the base are controlled separately, thereby the temperature in the reaction chamber may be maintained at the first temperature at which an inner wall of the reaction chamber will not be etched, and the temperature of the base is controlled at the second temperature which is lower than the first temperature. In this way, after the etching process for removing a surface oxide such as  $\text{SiO}_2$  is performed on the workpiece being processed supported by the base, the temperature of the workpiece being processed can satisfy a temperature requirement for directly performing a subsequent process, which obviates the need for cooling the workpiece being processed. In this way, it obviates the need for integrating an annealing function or an annealing chamber in the etching chamber, and accordingly, it obviates the need for providing a separate cooling chamber. Therefore, only the etching chamber is required to be provided for the gas phase etching apparatus and equipment, which is simple in structure, short in process routes, inexpensive in cost, and high in production capacity. Such a single chamber structure (only the etching chamber is required, and the annealing chamber and the cooling chamber are not required) is more beneficial to integrate with a subsequent process. That is, it is easier to integrate the single chamber structure with an apparatus required by the subsequent process on a same platform, such that the flexibility in use is better.

(2) Because the gas phase etching apparatus and equipment provided by the present disclosure are used in the gas phase etching process, that is, the oxide layer of  $\text{SiO}_2$  on the surface of the workpiece being processed is removed using the gas phase etching process, instead of the plasma etching process used in the prior art, when the oxide layer of  $\text{SiO}_2$  on the surface of the workpiece being processed is removed using the gas phase etching apparatus and equipment provided by the present disclosure, no reaction product in the solid state will be generated. In this way, reaction products are easy to be extracted from the

chamber by a pump, such that the problem that the reaction products in the solid state block small holes in the prior art can be avoided, which not only is beneficial to remove the layer of SiO<sub>2</sub> at bottoms of small holes, but also improves the overall cleaning efficiency of the oxide layer of SiO<sub>2</sub>.

(3) Further, when the oxide layer of SiO<sub>2</sub> on the surface of the workpiece being processed is removed using the gas phase etching apparatus and equipment provided by the present disclosure, it needs to perform the process under a high pressure (for example, the pressure in the reaction chamber is in a range of 30Torr-300Torr). In this way, the etchant is more easily absorbed on the surface of the workpiece being processed (such as a silicon wafer), which can speed up the rate of the reaction, improving the etch selectivity ratio.

It should be understood by a person skilled in the art that the purpose of the above description of the embodiments of the present disclosure is only for exemplarily illustrating the beneficial effects of the embodiments of the present disclosure, and is not intended to limit the embodiments of the present disclosure to any given examples.

The embodiment of the present disclosure has been described above, and the above description is exemplary, not exhaustive and not limited to the disclosed embodiments. Various modifications and variants to this disclosure are obvious for a person skilled in the art that, without departing from the scope and the spirit of the disclosed embodiments. Selection of terms used herein, is intended for best explanation of principles of embodiments, practical applications or improvement of technology in commercial use, or for enabling others ordinarily skilled in the art to understand embodiments disclosed herein.

What is claimed is:

1. A gas phase etching apparatus, comprising:

a reaction chamber body, which defines a space for forming a reaction chamber;

a base, which is arranged within the reaction chamber and configured to support a workpiece being processed;

a gas intake element, which is connected to the reaction chamber body and configured to introduce an etchant into the reaction chamber; and

a pressure control component, which is connected to the reaction chamber body and configured to control a pressure in the reaction chamber,

wherein, the apparatus further comprises:

a first temperature controller, which is connected to the reaction chamber body and configured to control a temperature in the reaction chamber to a first temperature, the first temperature being a temperature at which the reaction chamber is not corroded by the etchant; and

a second temperature controller, which is connected to the base and configured to control a temperature of the base to a second temperature, the second temperature being a temperature at which the workpiece being processed supported by the base satisfies a temperature requirement for directly performing a subsequent process; and

a lining component, which is placed in an inner space of the reaction chamber body and configured to cover a sidewall of the reaction chamber body;

wherein the lining component comprises a first liner and a second liner, a reaction by-product enters the pressure control component at least via a gap between the base and the first liner and a gap between the first liner and the second liner.

2. The gas phase etching apparatus of claim 1, wherein the first temperature controller controls the temperature in the reaction chamber to the first temperature through heat conduction, heat radiation and/or heat convection by controlling gas, liquid or solid media; and/or

the second temperature controller controls the temperature of the base to the

second temperature through heat conduction, heat radiation and/or heat convection by controlling gas, liquid or solid media.

3. The gas phase etching apparatus of claim 2, wherein the first temperature is in a range of 50°C-90°C.

4. The gas phase etching apparatus of claim 2, wherein the second temperature is in a range of 20°C-60°C.

5. The gas phase etching apparatus of claim 1, wherein the pressure control component comprises:

a pressure controller, which is configured to adjust a pressure in the reaction chamber to be in a range of 30Torr~300Torr to improve an etch selectivity ratio.

6. The gas phase etching apparatus of claim 1, further comprising:

a showerhead, which is located in an upper region of the reaction chamber and connected to the gas intake element;

wherein the showerhead comprises an upper uniform flow plate and a lower uniform flow plate, the etchant enters the reaction chamber via the upper uniform flow plate and the lower uniform flow plate of the showerhead, and

wherein a size of a hole of the upper uniform flow plate is larger than that of the lower uniform flow plate.

7. The gas phase etching apparatus of claim 1, wherein the gap between the base and the first liner is smaller than the gap between the first liner and the second liner.

8. The gas phase etching apparatus of claim 1, wherein the gas intake element introduces a dehydrated hydrogen fluoride gas and a dehydrated alcohol gas into the reaction chamber; and

the dehydrated hydrogen fluoride gas and the dehydrated alcohol gas are mixed to remove silicon dioxide on the workpiece being processed.

9. A gas phase etching equipment, comprising: a transferring apparatus and the gas phase etching apparatus of any one of claims 1 to 8, wherein the transferring apparatus is connected to the gas phase etching apparatus such that the workpiece being processed is transferred between the transferring apparatus and the gas phase etching apparatus.