

PROCESS CHAMBER CLEANLINESS DETECTION METHOD AND PROCESS CHAMBER

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TECHNICAL FIELD

[0001] The present disclosure relates to the field of process chambers, and specifically relates to a process chamber cleanliness detection method and a process chamber.

BACKGROUND

10 [0002] Semiconductor process devices are widely used in the manufacturing of integrated circuits (ICs) or MEMS devices. The plasma contains a large number of active particles like electrons, ions, excited atoms, molecules, radicals and neutral groups, which reach a surface of a wafer under the action of a bias voltage, and interact with the wafer to cause various physical and chemical reactions on the surface of the material, thereby
15 generating a large number of particles. Most of the particles are cleared after the process, but a small number of particles will adhere to the inner wall of the process chamber, and fall off after accumulation or be decomposed onto the surface of the wafer in the process, causing wafer etching defects.

[0003] In the related process, to prevent the particles attached to the inner wall of the
20 process chamber from causing etching defects on the surface of the wafer, a wafer to be detected is typically introduced for a specific detection process after the semiconductor processes of N wafers (where each wafer takes a process period) are performed in the process chamber, and after the detection process is finished, a particle detector is used to detect whether a change in the number of particles over 60nm on the surface of the wafer
25 before and after the wafer enters the chamber is less than 50, thereby judging whether the cleanliness of the chamber meets the process requirements. If the cleanliness of the chamber does not meet the process requirements, a specific waferless automatic clean (WAC) process is performed on the chamber until the chamber cleanliness detection result meets the process requirements, and then, a semiconductor process, such as etching and
30 the like, is started again.

[0004] However, the existing particle detection and cleaning scheme for the process

chamber requires the aid of an external device at the beginning of each process, which is time-consuming, while the cleanliness of the inner wall of the process chamber depends on the accuracy of the WAC process, and the condition of polymer buildup on the inner wall of the chamber after cleaning cannot be clearly determined. Therefore, this solution
5 can only alleviate the problem of particles, but cannot ensure complete cleaning of the process chamber. As a result, particles remaining on the inner wall of the process chamber may still fall onto the wafer surface during processing, causing wafer etching defects and reducing the product yield.
[0005] Therefore, how to provide a process chamber cleanliness detection method that
10 can ensure the cleanliness of the inner wall of the process chamber has become an urgent technical problem to be solved in the art.

SUMMARY

[0006] The present disclosure aims to provide a process chamber cleanliness detection
15 method and a process chamber which can ensure cleanliness of an inner wall of a process chamber.

[0007] In order to achieve the above object, as an aspect of the present disclosure, there is provided a process chamber cleanliness detection method, wherein the process chamber includes a chamber body, and at least one crystal oscillator fixedly disposed on the
20 chamber body and having a deposition detection surface facing an interior of the chamber body, and the process chamber cleanliness detection method includes:

[0008] detecting a current natural frequency of the crystal oscillator;
[0009] determining, based on the current natural frequency of the crystal oscillator, a
corresponding thickness of a deposited film layer on an inner wall of the chamber body;
25 and

[0010] when the thickness of the deposited film layer exceeds a first preset thickness threshold, determining that the process chamber needs to be cleaned.

[0011] In some embodiments, the method further includes:
[0012] after the process chamber is cleaned, detecting a current natural frequency of the
30 crystal oscillator;

[0013] determining, based on the current natural frequency of the crystal oscillator, a corresponding thickness of a deposited film layer on the inner wall of the chamber body;
and

[0014] when the thickness of the deposited film layer exceeds a second preset thickness threshold, cleaning the process chamber again, and when the thickness of the deposited film layer is less than or equal to the second preset thickness threshold, ending the cleaning of the process chamber.

5 [0015] As a second aspect of the present disclosure, there is provided a process chamber, including a chamber body, and at least one crystal oscillator fixedly disposed on the chamber body and having a deposition detection surface facing an interior of the chamber body, wherein a current natural frequency of the crystal oscillator represents a cleanness of the process chamber.

10 [0016] In some embodiments, the chamber body includes a chamber main body and an upper cover, wherein the upper cover is configured to seal a top opening of the chamber main body, a first mounting slot is formed in a top surface of the upper cover, and a first mounting hole penetrating to a bottom surface of the upper cover is formed at a bottom of the first mounting slot, and the process chamber further includes a plurality of connection
15 lines, the crystal oscillator is disposed in the first mounting hole, and the plurality of connection lines are connected to electrodes of the crystal oscillator through the first mounting slot.

[0017] In some embodiments, the process chamber further includes a sleeve disposed in the first mounting slot, wherein a bottom of the sleeve is in sealed connection with the
20 bottom of the first mounting slot, and the sleeve is formed therein with a first connection hole extending in an axial direction of the sleeve, through which the plurality of connection lines are connected to the electrodes of the crystal oscillator.

[0018] In some embodiments, a second mounting slot is formed on an outer sidewall of the chamber body, wherein a second mounting hole penetrating to an inner sidewall of the
25 chamber body is formed at a bottom of the second mounting slot, the process chamber further includes a plurality of connection lines, the crystal oscillator is disposed in the second mounting hole, and the plurality of connection lines are connected to electrodes of the crystal oscillator through the second mounting slot.

[0019] In some embodiments, the process chamber further includes an airtight valve plate
30 disposed in the second mounting slot, wherein the airtight valve plate is in sealed connection with the second mounting slot, and the airtight valve plate is formed therein with a second connection hole, through which the plurality of connection lines are connected to the electrodes of the crystal oscillator.

[0020] In some embodiments, the process chamber further includes a mounting valve

plate and wiring connectors, wherein the mounting valve plate is fixedly disposed on an outer wall of the chamber body and positioned in one-to-one correspondence with the crystal oscillator, a plurality of avoidance through holes penetrating through the mounting valve plate in a thickness direction of the mounting valve plate are formed in the mounting
5 valve plate, and the plurality of connection lines corresponding to each crystal oscillator pass through the plurality of avoidance through holes in the corresponding mounting valve plate in one-to-one correspondence; and

[0021] the wiring connectors seal the plurality of avoidance through holes in one-to-one correspondence, and fixedly connect the connection lines to the mounting valve plate.

10 [0022] In some embodiments, a protective film is provided on the deposition detection surface of the crystal oscillator, wherein the protective film is made of a material including yttria.

[0023] In some embodiments, the process chamber further includes a controller electrically connected to the crystal oscillator, wherein the controller is configured to
15 detect a current natural frequency of the crystal oscillator, and judge, based on the current natural frequency, whether to clean the process chamber.

[0024] In some embodiments, the controller is further configured to detect, after the process chamber is cleaned, a current natural frequency of the crystal oscillator, and judge, based on the current natural frequency, whether to end cleaning of the process chamber.

20 [0025] According to the process chamber cleanliness detection method and the process chamber provided in the present disclosure, the crystal oscillator has a deposition detection surface facing the interior of the chamber body, so that when particles or polymers are deposited on the inner wall of the chamber body in a semiconductor process and form a film, the film may be also deposited on the deposition detection surface of the
25 crystal oscillator to change the overall thickness of the crystal oscillator, and thus change the natural frequency of the crystal oscillator. Since the natural frequency of the crystal oscillator is changed linearly with the thickness of the film, a corresponding thickness of the deposited film layer on the inner wall of the chamber body can be determined from a current natural frequency of the crystal oscillator, and when the thickness of the deposited
30 film layer exceeds a first preset thickness threshold, it can be determined timely that the process chamber needs to be cleaned.

[0026] By determining the thickness of the deposited film layer through the crystal oscillator in the process chamber, the present disclosure can enable real-time and accurate monitoring of an interior state of the process chamber without introducing the wafer to be

detected and performing the specific detection process, thereby improving the efficiency of process chamber maintenance, ensuring the semiconductor process effect, and increasing the wafer product yield.

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BRIEF DESCRIPTION OF DRAWINGS

[0027] Accompanying drawings are provided for further understanding of the present disclosure and constitute a part of the specification. Hereinafter, these drawings are intended to explain the present disclosure together with the following specific implementations, but should not be considered as a limitation of the present disclosure. In the drawings:

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[0028] FIG. 1 is a schematic structural view of a process chamber according to an embodiment of the present disclosure;

[0029] FIG. 2 is an enlarged partial view of region A in the process chamber of FIG. 1;

[0030] FIG. 3 is an enlarged partial view of region B in the process chamber of FIG. 1;

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[0031] FIG. 4 is a partial structural view of a process chamber according to an embodiment of the present disclosure;

[0032] FIG. 5 is a schematic structural view of a process chamber according to an embodiment of the present disclosure;

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[0033] FIG. 6 is a schematic structural view of a process chamber according to another embodiment of the present disclosure;

[0034] FIG. 7 is a schematic flowchart of a process chamber cleanliness detection method according to an embodiment of the present disclosure;

[0035] FIG. 8 is a schematic flowchart of a process chamber cleanliness detection method according to another embodiment of the present disclosure;

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[0036] FIG. 9 is a schematic flowchart of a process chamber cleanliness detection method according to another embodiment of the present disclosure;

[0037] FIG. 10 is a graph of natural frequencies of a crystal oscillator as a function of thicknesses.

[0038] List of reference signs:

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100: chamber body

110: chamber main body

120: upper cover

210: crystal oscillator

220: connection line

310: mounting valve plate

311: fixing through hole

320: wiring connector

410: sleeve	420: airtight gasket
430: airtight valve plate	10: wafer
1: industrial personal computer	2: control module.

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DETAIL DESCRIPTION OF EMBODIMENTS

[0039] Hereinafter, specific implementations of the present disclosure will be described with respect to the accompanying drawings. It will be appreciated that the specific implementations as set forth herein are merely for the purpose of illustration and explanation of the present disclosure and should not be constructed as a limitation thereof.

10 [0040] To solve the above technical problem, as one aspect of the present disclosure, there is provided a process chamber cleanliness detection method applied to a process chamber. As shown in FIG. 1, the process chamber is configured to accommodate a wafer 10, and perform a semiconductor process on the wafer 10 introduced into the process chamber. The process chamber includes a chamber body 100, and at least one crystal
15 oscillator 210 fixedly disposed on the chamber body 100 and having a deposition detection surface facing an interior of the chamber body 100. As shown in FIG. 7, the process chamber cleanliness detection method includes the following operations S1 to S3.

[0041] At operation S1, a current natural frequency of the crystal oscillator 210 is detected.

20 [0042] At operation S2, based on the current natural frequency of the crystal oscillator 210, a corresponding thickness of a deposited film layer on an inner wall of the chamber body 100 is determined.

[0043] At operation S3, when the thickness of the deposited film layer exceeds a first preset thickness threshold, it is determined that the process chamber needs to be cleaned.

25 [0044] The natural frequency of the crystal oscillator 210 due to the piezoelectric effect depends on its geometry, cut type and thickness, and is calculated as:

$$f \cdot d = v/2;$$

where f is the natural frequency of the crystal oscillator 210, d is a thickness of the crystal oscillator 210, and v is a shear wave velocity of the crystal oscillator 210.

30 [0045] When particles are accumulated on the deposition detection surface of the crystal oscillator 210 and cause a thickness change of Δd , a mass load effect may occur to cause a change Δf in the natural frequency of the crystal oscillator 210, which is calculated as:

$$\Delta f = \left(-\frac{v}{2d^2}\right) \Delta d.$$

[0046] That is, the thickness change (Δd) caused by particle accumulation on the deposition detection surface of the crystal oscillator 210 is linearly correlated with the natural frequency change (Δf) of the crystal oscillator. As the particle accumulation on the inner wall of the chamber increases, a polymer thickness on the deposition detection surface of the crystal oscillator 210 increases, and the natural frequency of the crystal oscillator 210 monotonically and linearly decreases (theoretically, when a crystal oscillator 210 with a natural frequency of 5MHz to 10MHz is selected, a maximum allowable decrease of the fundamental frequency is 2% to 3%, and a change in a thickness of the crystal oscillator 210 may be in a range of 0.1nm to 10 μ m). FIG. 10 shows a graph of natural frequencies of the crystal oscillator 210 as a function of thicknesses.

[0047] In an embodiment of the present disclosure, the crystal oscillator 210 has a deposition detection surface facing the interior of the chamber body 100, so that when particles or polymers are deposited on the inner wall of the chamber body 100 in a semiconductor process and form a film, the film may be also deposited on the deposition detection surface of the crystal oscillator 210 to change the overall thickness of the crystal oscillator 210, and thus change the natural frequency of the crystal oscillator 210. As can be seen from the above analysis, the natural frequency of the crystal oscillator 210 is changed linearly with the thickness of the film.

[0048] Therefore, the process chamber cleanliness detection method of the present disclosure can determine the thickness of the deposited film layer on the inner wall of the corresponding chamber body 100 from the current natural frequency of the crystal oscillator 210 based on a pre-stored parameter related to the linear relationship between natural frequencies of the crystal oscillator 210 and thicknesses of the film layer, and further timely determine that the process chamber needs to be cleaned when the thickness of the deposited film layer exceeds a first preset thickness threshold.

[0049] In some embodiments, when the thickness of the deposited film layer is less than or equal to the first preset thickness threshold, the process chamber does not need to be cleaned, and the semiconductor process on the wafer can be continued.

[0050] According to the process chamber cleanliness detection method of the present disclosure, by determining the thickness of the deposited film layer through the crystal oscillator 210 in the process chamber, the present disclosure can enable real-time and accurate monitoring of an interior state of the process chamber without introducing the

wafer to be detected and performing the specific detection process, thereby improving the efficiency of process chamber maintenance, ensuring the semiconductor process effect, and increasing the wafer product yield.

[0051] As an implementation of the present disclosure, as shown in FIG. 8, the process chamber cleanliness detection method further includes the following operation S4.

[0052] At operation S4, the process chamber is cleaned upon determining that the process chamber needs to be cleaned.

[0053] To ensure the cleaning effect of the chamber body 100, as an implementation of the present disclosure, as shown in FIG. 9, the method further includes the following operations S41 to S43.

[0054] At operation S41, after the process chamber is cleaned (i.e., after S4), a current natural frequency of the crystal oscillator 210 is detected.

[0055] At operation S42, based on the current natural frequency of the crystal oscillator 210, a corresponding thickness of a deposited film layer on an inner wall of the chamber body 100 is determined.

[0056] At operation S43, when the thickness of the deposited film layer exceeds a second preset thickness threshold, the process chamber is cleaned again (i.e., turning to operation S4), and when the thickness of the deposited film layer is less than or equal to the second preset thickness threshold, ending the cleaning of the process chamber.

[0057] In the embodiment of the present disclosure, after the interior of the chamber body 100 is cleaned, the thickness of the deposited film layer on the inner wall of the chamber body 100 is determined again, and then, it is judged whether the cleaning effect of the chamber meets the requirements by comparing a thickness of the deposited film layer with the preset second thickness threshold, thereby ensuring the cleaning effect of the chamber body 100, and thus ensuring the semiconductor process effect.

[0058] As an implementation of the present disclosure, the process chamber cleanliness detection method further includes:

[0059] the semiconductor process is cycled, and operations S1 to S3 are performed each time before the semiconductor process is performed, to ensure that the process chamber meets the cleanliness requirement before the semiconductor process is performed.

[0060] As a second aspect of the present disclosure, there is provided a process chamber, including a chamber body 100, and at least one crystal oscillator 210 fixedly disposed on the chamber body 100 and having a deposition detection surface facing an interior of the chamber body 100. A current natural frequency of the crystal oscillator 210 represents a

cleanness of the process chamber.

[0061] In the embodiment of the present disclosure, the crystal oscillator 210 has a deposition detection surface facing the interior of the chamber body 100, and the current natural frequency of the crystal oscillator 210 represents the cleanness of the process chamber, so that when particles or polymers are deposited on the inner wall of the chamber body 100 in a semiconductor process and form a film, the film may be also deposited on the deposition detection surface of the crystal oscillator 210 to change the overall thickness of the crystal oscillator 210, and thus change the natural frequency of the crystal oscillator 210. Therefore, the thickness of the deposited film layer on the inner wall of the corresponding chamber body 100 can be determined from the current natural frequency of the crystal oscillator 210 based on a pre-stored parameter related to the linear relationship between natural frequencies of the crystal oscillator 210 and thicknesses of the film layer, and further, it can be timely determined that the process chamber needs to be cleaned when the thickness of the deposited film layer exceeds a first preset thickness threshold.

[0062] By determining the thickness of the deposited film layer through the crystal oscillator 210 in the process chamber, the process chamber of the present disclosure can enable real-time and accurate monitoring of an interior state of the process chamber without introducing the wafer to be detected and performing the specific detection process, thereby improving the efficiency of process chamber maintenance, ensuring the semiconductor process effect, and increasing the wafer product yield.

[0063] As an implementation of the present disclosure, as shown in FIG. 1, the chamber body 100 includes a chamber main body 110 and an upper cover 120. The upper cover 120 is configured to seal a top opening of the chamber main body 110.

[0064] As an implementation of the present disclosure, the process chamber further includes a controller electrically connected to the crystal oscillator 210 (via connection lines 220). The controller is configured to detect a current natural frequency of the crystal oscillator 210, and judge, based on the current natural frequency, whether to clean the process chamber, i.e., whether to implement the process chamber cleanliness detection method provided in the embodiments of the present disclosure.

[0065] As an implementation of the present disclosure, the controller is further configured to detect, after the process chamber is cleaned, a current natural frequency of the crystal oscillator, and judge, based on the current natural frequency, whether to end cleaning of the process chamber, thereby ensuring the cleaning effect of the chamber body

100, and further ensuring the semiconductor process effect. For example, a corresponding thickness of the deposited film layer on the inner wall of the chamber body 100 can be determined from a current natural frequency of the crystal oscillator 210. When the thickness of the deposited film layer exceeds a second preset thickness threshold, the process chamber is cleaned again (i.e., operation S4 is performed), and when the thickness of the deposited film layer is less than or equal to the second preset thickness threshold, the cleaning of the process chamber is ended.

[0066] As an implementation of the present disclosure, as shown in FIGs. 5 and 6, the controller may include an industrial personal computer 1 and a control module 2. The control module 2 is internally provided with an oscillation circuit acquire a current natural frequency of the crystal oscillator 210, calculate a thickness of a film layer on the surface of the crystal oscillator 210, and transmit data to the industrial personal computer 1. The industrial personal computer 1 is configured to compare the data and decide a next process (such as whether to perform a semiconductor process or clean the process chamber).

[0067] As an implementation of the present disclosure, as shown in FIG. 2, a first mounting slot is formed in a top surface of the upper cover 120, and a first mounting hole penetrating to a bottom surface of the upper cover 120 is formed at a bottom of the first mounting slot, and the process chamber further includes a plurality of connection lines 220, the crystal oscillator 210 is disposed in the first mounting hole, and the plurality of connection lines 220 are connected to electrodes of the crystal oscillator 210 through the first mounting slot.

[0068] To ensure the airtightness of the chamber body 100, as an implementation of the present disclosure, as shown in FIG. 2, the process chamber further includes a sleeve 410 disposed in the first mounting slot. A bottom of the sleeve 410 is in sealed connection with the bottom of the first mounting slot, and the sleeve 410 is formed therein with a first connection hole extending in an axial direction of the sleeve 410, through which the plurality of connection lines 220 are connected to the electrodes of the crystal oscillator 210.

[0069] In the embodiment of the present disclosure, the sleeve 410 is disposed in the first mounting slot, and may be in sealed connection with the bottom of the first mounting slot while protecting the connection line 220, so that the internal environment of the chamber body 100 is prevented from being communicated with the outside through a clearance between the crystal oscillator 210 and the first mounting hole, and the airtightness of the chamber body 100 is ensured.

[0070] As an implementation of the present disclosure, as shown in FIG. 2, the deposition detection surface of the crystal oscillator 210 is flush with a bottom surface of the upper cover 120, so that the thickness of the film layer deposited on the deposition detection surface is ensured to be consistent with the thickness of the film layer deposited on the inner wall of the chamber body 100.

[0071] To further ensure the airtightness of the chamber body 100, as an optimal implementation of the present disclosure, the sleeve 410 includes a main body part and a positioning part which are sequentially connected in the axial direction of the sleeve 410. The main body part is disposed in the first mounting slot, and a cross-sectional shape of the main body part corresponds to a cross-sectional shape of the first mounting slot, while a cross-sectional shape of the positioning part corresponds to a cross-sectional shape of the first mounting hole, and a bottom end of the positioning part is inserted into the first mounting hole.

[0072] The process chamber further includes an airtight gasket 420 sleeved on the positioning part, such that the bottom of the sleeve 410 is in a sealed connection with the bottom of the first mounting slot.

[0073] In an embodiment of the present disclosure, the sleeve 410 has a stepped design, and the step is in fit and sealed connection with the bottom of the first mounting slot through the airtight gasket 420, thereby further ensuring the airtightness of the chamber body 100.

[0074] As an implementation of the present disclosure, the sleeve 410 is made of ceramic.

[0075] As an implementation of the present disclosure, as shown in FIG. 3, a second mounting slot is formed on an outer sidewall of the chamber body 100, and a second mounting hole penetrating to an inner sidewall of the chamber body 100 is formed at a bottom of the second mounting slot. The process chamber further includes connection lines 220, the crystal oscillator 210 is disposed in the second mounting hole, and a plurality of connection lines 220 are connected to electrodes of the crystal oscillator 210 through the second mounting slot.

[0076] To ensure the airtightness of the chamber body 100, as an implementation of the present disclosure, as shown in FIG. 3, the process chamber further includes an airtight valve plate 430 disposed in the second mounting slot. The airtight valve plate 430 is in sealed connection with the second mounting slot, and the airtight valve plate 430 is formed therein with a second connection hole, through which the plurality of connection lines 220 are connected to the electrodes of the crystal oscillator 210. The electrodes of each crystal

oscillator 210 are connected to the controller through the connection lines 220.

[0077] As an implementation of the present disclosure, as shown in FIG. 3, the deposition detection surface of the crystal oscillator 210 is flush with an inner sidewall of the chamber body 100, so that the thickness of the film layer deposited on the deposition detection surface is ensured to be consistent with the thickness of the film layer deposited on the inner wall of the chamber body 100.

[0078] As an optimal implementation of the present disclosure, as shown in FIGs. 2 to 4, the process chamber further includes a mounting valve plate 310 and wiring connectors 320. The mounting valve plate 310 is fixedly disposed on an outer wall of the chamber body 100 and positioned in one-to-one correspondence with the crystal oscillator 210, a plurality of avoidance through holes penetrating through the mounting valve plate 310 in a thickness direction of the mounting valve plate 310 are formed in the mounting valve plate 310, and the plurality of connection lines 220 corresponding to each crystal oscillator 210 pass through the plurality of avoidance through holes in the corresponding mounting valve plate 310 in one-to-one correspondence. The wiring connectors 320 seal the plurality of avoidance through holes in one-to-one correspondence, and fixedly connect the connection lines 220 to the mounting valve plate 310.

[0079] Specifically, as shown in FIG. 2, under the condition that the first mounting slot is formed in the top surface of the upper cover 120 and the sleeve 410 is disposed in the first mounting slot, the mounting valve plate 310 corresponding to the sleeve 410 is fixedly disposed on the top surface of the upper cover 120, and seals an opening of the first mounting slot in the top surface of the upper cover 120.

[0080] As shown in FIG. 3, under the condition that the second mounting slot is formed in the outer sidewall of the chamber body 100 and the airtight valve plate 430 is disposed in the second mounting slot, the mounting valve plate 310 corresponding to the airtight valve plate 430 is fixedly disposed on the outer sidewall of the chamber body 100, and seals an opening of the second mounting slot in the outer sidewall of the chamber body 100.

[0081] In an embodiment of the present disclosure, the mounting valve plate 310 is further mounted on an outer side of the sleeve 410 and/or the airtight valve plate 430. The mounting valve plate 310 can be fixedly connected to the surface of the chamber body 100 from the outer side, and seal the opening of the first mounting slot or the second mounting slot, thereby further ensuring the airtightness of the chamber body 100. Moreover, the wiring connectors 320 fixedly connect the connection lines 220 to the

mounting valve plate 310, so that a part of each connection line 220 located between the crystal oscillator 210 and the mounting valve plate 310 can be fixed through the mounting valve plate 310 to avoid vibration and torsion of the connection lines 220 in this region that may cause displacement of the crystal oscillator 210, thereby ensuring stable positioning of the crystal oscillator 210, and thus guaranteeing a stable monitoring result inside the chamber.

[0082] As an implementation of the present disclosure, as shown in FIG. 4, a plurality of fixing through holes 311 penetrating through the mounting valve plate 310 in a thickness direction of the mounting valve plate 310 are formed in the mounting valve plate 310, a plurality of fixing holes are formed in an outer wall of the chamber body 100, and the mounting valve plate 310 is fixedly connected to the chamber body 100 by fasteners sequentially passing through the fixing through holes 311 and the corresponding fixing holes.

[0083] As an implementation of the present disclosure, the wiring connectors 320 are welded to the connection lines 220 and the mounting valve plate 310.

[0084] As an implementation of the present disclosure, a protective film is provided on the deposition detection surface of the crystal oscillator 210, and the protective film is made of a material including yttria.

[0085] As an implementation of the present disclosure, a high-purity thin film may be prepared by vacuum electron beam evaporation. Specifically, yttria (which is white powder at room temperature) may be bombarded by a high-energy electron beam in a high vacuum environment to reach a molten state. When a saturated vapor pressure is reached, the material is evaporated into a gaseous state to fill the chamber. A crystal oscillator is placed at an upper position inside the chamber, and at this time, the gaseous yttria particles are condensed into a film on a surface of the crystal oscillator, to gradually form an yttria thin film with a certain thickness.

[0086] It will be appreciated that the above implementations are merely exemplary implementations for the purpose of illustrating the principle of the present disclosure, and the present disclosure is not limited thereto. Various modifications and improvements can be made by a person having ordinary skill in the art without departing from the spirit and essence of the present disclosure. Accordingly, all of the modifications and improvements also fall within the protection scope of the present disclosure.

What is claimed is:

1. A process chamber cleanliness detection method, wherein the process chamber comprises a chamber body, and at least one crystal oscillator fixedly disposed on the chamber body and having a deposition detection surface facing an interior of the chamber body, wherein the process chamber cleanliness detection method comprises:

detecting a current natural frequency of the crystal oscillator;
determining, based on the current natural frequency of the crystal oscillator, a corresponding thickness of a deposited film layer on an inner wall of the chamber body; and

in response to the thickness of the deposited film layer exceeding a first preset thickness threshold, determining that the process chamber needs to be cleaned.

2. The process chamber cleanliness detection method according to claim 1, further comprising:

after the process chamber is cleaned, detecting a current natural frequency of the crystal oscillator;
determining, based on the current natural frequency of the crystal oscillator, a corresponding thickness of a deposited film layer on the inner wall of the chamber body; and

in response to the thickness of the deposited film layer exceeding a second preset thickness threshold, cleaning the process chamber again, and in response to the thickness of the deposited film layer being less than or equal to the second preset thickness threshold, ending the cleaning of the process chamber.

3. A process chamber, comprising a chamber body, and at least one crystal oscillator fixedly disposed on the chamber body and having a deposition detection surface facing an interior of the chamber body, wherein a current natural frequency of the crystal oscillator represents a cleanliness of the process chamber.

4. The process chamber according to claim 3, wherein the chamber body comprises a chamber main body and an upper cover, the upper cover is configured to seal a top opening of the chamber main body, a first mounting slot is formed in a top

surface of the upper cover, and a first mounting hole penetrating to a bottom surface of the upper cover is formed at a bottom of the first mounting slot, and the process chamber further comprises a plurality of connection lines, the crystal oscillator is disposed in the first mounting hole, and the plurality of connection lines are connected to electrodes of the crystal oscillator through the first mounting slot.

5. The process chamber according to claim 4, wherein the process chamber further comprises a sleeve disposed in the first mounting slot, a bottom of the sleeve is in sealed connection with the bottom of the first mounting slot, and the sleeve is formed therein with a first connection hole extending in an axial direction of the sleeve, through which the plurality of connection lines are connected to the electrodes of the crystal oscillator.

6. The process chamber according to claim 3, wherein a second mounting slot is formed on an outer sidewall of the chamber body, a second mounting hole penetrating to an inner sidewall of the chamber body is formed at a bottom of the second mounting slot, the process chamber further comprises a plurality of connection lines, the crystal oscillator is disposed in the second mounting hole, and the plurality of connection lines are connected to electrodes of the crystal oscillator through the second mounting slot.

7. The process chamber according to claim 6, wherein the process chamber further comprises an airtight valve plate disposed in the second mounting slot, the airtight valve plate is in sealed connection with the second mounting slot, and the airtight valve plate is formed therein with a second connection hole, through which the plurality of connection lines are connected to the electrodes of the crystal oscillator.

8. The process chamber according to any one of claims 4 to 7, wherein the process chamber further comprises a mounting valve plate and wiring connectors, the mounting valve plate is fixedly disposed on an outer wall of the chamber body and positioned in one-to-one correspondence with the crystal oscillator, a plurality of avoidance through holes penetrating through the mounting valve plate in a thickness direction of the mounting valve plate are formed in the mounting valve plate, and the plurality of connection lines corresponding to each crystal oscillator pass through the plurality of avoidance through holes in the corresponding mounting valve plate in one-

to-one correspondence; and

the wiring connectors seal the plurality of avoidance through holes in one-to-one correspondence, and fixedly connect the plurality of connection lines to the mounting valve plate.

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9. The process chamber according to any one of claims 3 to 7, wherein a protective film is provided on the deposition detection surface of the crystal oscillator, and the protective film is made of a material comprising yttria.

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10. The process chamber according to any one of claims 3 to 7, wherein the process chamber further comprises a controller electrically connected to the crystal oscillator, wherein the controller is configured to detect a current natural frequency of the crystal oscillator, and judge, based on the current natural frequency, whether to clean the process chamber.

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11. The process chamber according to claim 10, wherein the controller is further configured to detect, after the process chamber is cleaned, a current natural frequency of the crystal oscillator, and judge, based on the current natural frequency, whether to end cleaning of the process chamber.

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