

Description

Testing system for plasma properties in a reaction chamber, testing method and storage medium

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Technical Field

The disclosure relates to the field of semiconductor processing technology, in particular to a testing system for plasma properties in a reaction chamber, a processing apparatus for a semiconductor device, a testing method for plasma properties in a reaction chamber, and a computer-readable storage medium.

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Background

During a process of thin film deposition, radio frequency electrodes are used to generate high-frequency electric fields to provide energy for exciting the plasma. In order to avoid particle deposition and improve the productivity of the process of thin film deposition, a top cover of a reaction chamber is generally used as a radio frequency electrode in this field, and an alternating-current driven electric heating wire is installed inside it, to promote the thin film deposition reaction. However, direct contact between a metal armor on the surface of the heating wire and the top cover will cause alternating-current signal coupling on the surface of the top cover of the reaction chamber, resulting in certain alternating-current noise in the direct-current (DC) bias voltage signal collected by the top cover of the reaction chamber, which will seriously affect the accuracy of testing plasma properties in the reaction chamber through voltage testing.

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In order to overcome the above-mentioned shortcomings of existing technology, this field urgently needs a testing system for plasma properties in a reaction chamber, for filtering out alternating-current noise in a top cover voltage of a reaction chamber, to improve the accuracy of plasma properties testing results.

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Summary

A brief overview of one or more aspects is provided below to provide a basic understanding of these aspects. The summary is not an extensive overview of all of the aspects that are contemplated, and is not intended to identify key or decisive elements in all aspects. The sole purpose of the summary is to present some concepts of one or more aspects in a simplified form as a prelude to the more detailed description that is presented later.

In order to overcome the above-mentioned shortcomings of existing technologies, the present invention provides a testing system for plasma properties in a reaction chamber, a processing apparatus for a semiconductor device, a testing method for plasma properties in a reaction chamber, and a computer-readable storage medium, which can effectively filter out alternating-current noise in a top cover voltage of a reaction chamber, thereby improving the accuracy of plasma properties testing results.

Specifically, the testing system for plasma properties in a reaction chamber provided in the first aspect of the present invention comprises at least two sampling paths, a voltage processing module and a testing module. The at least two sampling paths are used to respectively collect voltage signals of a top cover of the reaction chamber. The top cover is used as a radio frequency electrode to excite plasma in the reaction chamber, and contacts an alternating-current driven heating wire. The voltage processing module is connected to a second sampling path, for shifting a phase of the voltage signal thereof by 180° , to obtain a second voltage signal, and adding the second voltage signal to a first voltage signal of an original phase on a first sampling path, to obtain a third voltage signal filtered out of alternating-current noise. The testing module is connected to the voltage processing module, to acquire the third voltage signal, and determine the plasma properties in the reaction chamber according to the third voltage signal.

Furthermore, in some embodiments of the disclosure, the voltage processing module comprises an odd number of inverting circuits, for shifting the phase of the voltage signal on the second sampling path by 180° , to obtain the second voltage signal. The voltage processing module comprises a plurality of phase shifting circuits, wherein the plurality of phase shifting circuits change the phase of the voltage signal

on the second sampling path by multiple stages, for shifting the phase of the voltage signal on the second sampling path by 180° , to obtain the second voltage signal.

Furthermore, in some embodiments of the disclosure, the voltage processing module comprises two phase shifting circuits. The two phase shifting circuits respectively shift the phase of the voltage signal on the second sampling path by 90° , to obtain the second voltage signal.

Furthermore, in some embodiments of the disclosure, the voltage processing module further comprises a signal superposition circuit. A first input terminal of the signal superposition circuit is connected to an output terminal of the first sampling path, to obtain the first voltage signal of the original phase. A second input terminal of the signal superposition circuit is connected to output terminals of the inverting circuits or the plurality of phase shifting circuits, to obtain the second voltage signal. An output terminal of the signal superposition circuit is connected to the testing module to output the third voltage signal filtered out of alternating-current noise.

Furthermore, in some embodiments of the disclosure, the voltage processing module further comprises a voltage restoration circuit. The output terminal of the signal superposition circuit is connected to the testing module through the voltage restoration circuit. The voltage restoration circuit reduces the third voltage signal by $1/2$ to obtain a fourth voltage signal, to characterize a direct-current voltage on the top cover, and transmits the fourth voltage signal to the testing module. The testing module determines the plasma properties in the reaction chamber according to the fourth voltage signal.

Furthermore, in some embodiments of the disclosure, the voltage processing module further comprises a first voltage sensor. An input terminal of the first voltage sensor is connected to an output terminal of the voltage processing module. An output terminal of the first voltage sensor is connected to an input terminal of the testing module, used for performing analog-to-digital conversion on the third voltage signal, and transmitting a converted third voltage data to the testing module, for determining the plasma properties in the reaction chamber according to the converted third voltage data.

Furthermore, in some embodiments of the disclosure, the voltage processing

module further comprises a second voltage sensor and a third voltage sensor. An input terminal of the second voltage sensor is connected to an output terminal of the first sampling path. An output terminal of the second voltage sensor is connected to an input terminal of the testing module, used for performing analog-to-digital conversion on the first voltage signal, and transmitting a converted first voltage data to the testing module. An input terminal of the third voltage sensor is connected to output terminals of the inverting circuits or the plurality of phase shifting circuits. An output terminal of the third voltage sensor is connected to the input terminal of the testing module, used for performing analog-to-digital conversion on the second voltage signal, and transmitting a converted second voltage data to the testing module, for the testing module summing the first voltage data and the second voltage data to determine a corresponding third voltage data, and determining the plasma properties in the reaction chamber according to the third voltage data.

In addition, according to the above-mentioned processing apparatus for a semiconductor device provided in the second aspect of the present invention comprises a reaction chamber, a heating wire, the testing system for plasma properties in a reaction chamber provided in the first aspect of the present invention and a radio frequency driving circuit. The reaction chamber comprises a top cover. The top cover is used as a radio frequency electrode, and contacts an alternating-current driven heating wire. The heating wire is connected to an alternating-current driving circuit, for heating the reaction chamber to promote a vapor deposition reaction of semiconductor processing. The testing system for plasma properties in a reaction chamber provided in the first aspect of the present invention is used for obtaining a voltage signal filtered out of alternating-current noise from the top cover, and determining the plasma properties in the reaction chamber according to the voltage signal. The radio frequency driving circuit is connected to the top cover and the testing system, used to drive the top cover to excite plasma in the reaction chamber according to a testing result of the plasma properties, to promote the vapor deposition reaction of semiconductor processing.

In addition, according to the above-mentioned testing method for plasma properties in a reaction chamber provided in the third aspect of the present invention

comprises following steps: respectively collecting voltage signals of a top cover of the reaction chamber through two sampling paths, wherein the top cover is used as a radio frequency electrode to excite plasma in the reaction chamber; shifting a voltage signal of a second sampling path by 180° , to obtain a second voltage signal; adding the second voltage signal to a first voltage signal of an original phase on a first sampling path, to obtain a third voltage signal filtered out of alternating-current noise; and determining the plasma properties in the reaction chamber, according to the third voltage signal.

In addition, according to the above-mentioned non-transitory computer-readable storage medium provided in the fourth aspect of the present invention stores a computer instruction thereon. The testing method for plasma properties in a reaction chamber provided in the third aspect of the present invention is implemented when the computer instruction is executed by a processor.

Brief Description of the Drawings

The above features and advantages of the present invention will be better understood after reading the detailed description of the embodiments of the present disclosure in conjunction with the following figures. In the figures, components are not necessarily drawn to scale, and components having similar related features may have the same or similar reference numerals.

Fig. 1 shows a schematic diagram of the structure of a processing apparatus for a semiconductor device provided according to some embodiments of the present invention.

Fig. 2 shows a circuit topology diagram of a voltage processing module provided according to some embodiments of the present invention.

Fig. 3 shows a flowchart of a testing method for plasma properties in a reaction chamber provided according to some embodiments of the present invention.

Fig. 4 shows a phase curve diagram at VF1 and VF2 nodes provided according to some embodiments of the present invention.

Fig. 5 shows a circuit topology diagram of a voltage processing module provided according to some embodiments of the present invention.

Fig. 6 shows a schematic diagram of the structure of a processing apparatus for a semiconductor device provided according to some embodiments of the present invention.

5	Reference signs	
	11	a heating wire
	12, 62	testing system for plasma properties in a reaction chamber
	121	a first sampling path
	122	a second sampling path
10	123	a voltage processing module
	124	a testing module
	125	a voltage sensor
	13	a radio frequency driving circuit
	14	a top cover
15	15	an alternating-current driving circuit
	21	inverting circuits
	22, 52	a signal superposition circuit
	23, 53	a voltage restoration circuit
	511, 512	a phase shifting circuit
20	621	a first sampling path
	622	a second sampling path
	623	a voltage processing module
	624	a testing module
	625, 626	a voltage sensor

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Detailed Description of Embodiments

The embodiments of the present invention are described in the following detailed description. Other advantages and effects of the present invention will be readily apparent to those skilled in the art from this disclosure. Although the description of the present invention will be described in conjunction with the preferred embodiments, this is not a limitation of the present invention. On the

contrary, the invention is described in connection with the embodiments so as to cover other alternatives or modifications that are possible in the embodiments of the present invention. In order to provide a thorough understanding of the present invention, many specific details are included in the following description. The present invention
5 may also be practiced without these details. In addition, some specific details are omitted in the description in order to avoid confusing or obscuring the present invention.

In the description of the present invention, it should be noted that the terms "installation", "connecting", and "connected" should be understood broadly unless
10 explicitly stated and defined otherwise. For example, the terms "installation", "connecting", and "connected" may be either a fixed connection, a detachable connection, or an integral connection; the terms may be either a mechanical connection or an electrical connection; the terms also may be either a direct connection, an indirect connection through an intermediate medium, or an internal
15 connection between two components. The specific meaning of the above terms in the present invention can be understood in a specific case by those skilled in the art.

In addition, "up", "down", "left", "right", "top", "bottom", "horizontal", "vertical" used in the following description shall be understood as the orientation described in the paragraph and shown in the related figure. The relative term is used
20 for convenience of description only, and does not mean that the device described therein is to be manufactured or operated in the specific orientation, and therefore should not be construed as limiting the present invention.

Understandably, although the terms "first", "second", "third", etc. may be used to describe various components, regions, layers and/or portions to distinguish
25 different components, regions, layers and/or portions, the order of these components, regions, layers and/or portions described above should not be limited by the terms. Therefore, a first component, region, layer and/or portion mentioned below may be also mentioned as a second component, region, layer and/or portion without departing from some embodiments of the present invention.

30 As mentioned above, direct contact between a metal armor on the surface of the heating wire and the top cover will cause alternating-current signal coupling on the

surface of the top cover of the reaction chamber, resulting in certain alternating-current noise in the direct-current (DC) bias voltage signal collected by the top cover of the reaction chamber, which will seriously affect the accuracy of testing plasma properties in the reaction chamber through voltage testing.

5 In order to overcome the above-mentioned shortcomings of existing technologies, the present invention provides a testing system for plasma properties in a reaction chamber, a processing apparatus for a semiconductor device, a testing method for plasma properties in a reaction chamber, and a computer-readable storage medium, which can effectively filter out alternating-current noise in a top cover
10 voltage of a reaction chamber, thereby improving the accuracy of plasma properties testing results.

In some non-limiting embodiments, the testing method for plasma properties in a reaction chamber provided in the third aspect of the present invention can be implemented by the testing system for plasma properties in a reaction chamber
15 provided in the first aspect of the present invention. Specifically, the testing system can be configured in the processing apparatus for a semiconductor device provided in the second aspect of the present invention, which is configured with a memory and a processor. The memory includes, but is not limited to, the computer-readable storage medium provided in the fourth aspect of the present invention, on which
20 computer instructions are stored. When the computer instructions are executed by the processor, the testing method for plasma properties in a reaction chamber provided in the third aspect of the present invention is implemented, thereby realizing the testing of plasma properties in the reaction chamber through the processing apparatus for a semiconductor device.

25 Firstly, please refer to Fig. 1, Fig. 1 shows a schematic diagram of the structure of a processing apparatus for a semiconductor device provided according to some embodiments of the present invention.

In the embodiment shown in Fig. 1, the processing apparatus for a semiconductor device provided in the present invention comprises a reaction chamber,
30 a heating wire 11, a testing system for plasma properties in a reaction chamber 12 and a radio frequency driving circuit 13. Herein, the reaction chamber comprises a top

cover 14. The top cover 14 is used as a radio frequency electrode, and contacts an alternating-current driven heating wire 11. The heating wire 11 is connected to an alternating-current driving circuit 15, for heating the reaction chamber to promote a vapor deposition reaction of semiconductor processing. The testing system for plasma properties in a reaction chamber 12 is used for obtaining a voltage signal filtered out of alternating-current noise from the top cover 14, and determining the plasma properties in the reaction chamber according to the voltage signal. The radio frequency driving circuit 13 is connected to the top cover 14 and the testing system 12, used to drive the top cover 14 to excite plasma in the reaction chamber according to a testing result of the plasma properties, to promote the vapor deposition reaction of semiconductor processing.

Furthermore, the testing system for plasma properties in a reaction chamber 12 provided in the present invention comprises at least two sampling paths 121 to 122, a voltage processing module 123 and a testing module 124. The at least two sampling paths 121 to 122 are used to respectively collect voltage signals of a top cover 14 of the reaction chamber. The voltage processing module 123 is connected to a second sampling path 122, for shifting a phase of the voltage signal thereof by 180° , to obtain a second voltage signal. Add the second voltage signal to a first voltage signal of an original phase on a first sampling path 121, to obtain a third voltage signal filtered out of alternating-current noise. The testing module 124 is connected to the voltage processing module 123, to acquire the third voltage signal, and determine the plasma properties in the reaction chamber according to the third voltage signal.

Please refer to Fig. 2 for details, Fig. 2 shows a circuit topology diagram of a voltage processing module provided according to some embodiments of the present invention.

In the embodiment shown in Fig. 2, the above-mentioned voltage processing module 123 comprises an odd number (including but not limited to 1, 3, 5) of inverting circuits 21, a signal superposition circuit 22 and a voltage restoration circuit 23. The inverting circuits 21 is composed of a first signal amplifier ICP1, related resistors R1, R2, R4, and a capacitor C1, for shifting the phase of the voltage signal on the second sampling path 122 by 180° , to obtain the second voltage signal. The

signal superposition circuit 22 is composed of a second signal amplifier ICP2 and related resistors R3, R5, R6, wherein a first input terminal of the signal superposition circuit is connected to an output terminal of the first sampling path 121, to obtain the first voltage signal of the original phase, and a second input terminal thereof is connected to output terminals of the inverting circuits 21, to obtain the inverted second voltage signal, for superimposing the first voltage signal and the second voltage signal, and outputting the third voltage signal filtered out of alternating-current noise after superposition to the voltage restoration circuit 23 through an output terminal thereof. The voltage restoration circuit 23 is composed of a third signal amplifier ICP3 and related resistors R8 and R9, wherein an input terminal is connected to the output terminal of the signal superposition circuit 22, and an output terminal thereof is connected to the testing module 124 at the back end, for reducing the third voltage signal by 1/2, to obtain a fourth voltage signal for characterizing the direct-current voltage on the top cover 14, and transmits the fourth voltage signal to the testing module 124, for determining the plasma properties in the reaction chamber according to the fourth voltage signal.

Those skilled in the art can understand the circuit topology architecture comprising the voltage restoration circuit 23 shown in Fig. 2 is only a non-limiting embodiment provided by the disclosure, aiming to clearly demonstrate the main concept of the disclosure and provide a specific solution for public implementation, rather than limiting the scope of protection of the disclosure.

Optionally, in other embodiments, those skilled in the art can also directly connect the output terminal of the signal superposition circuit 22 to the testing module 124 at the back end, for reducing the voltage or convert the obtained third voltage signal, thereby similarly achieving the purpose of determining the plasma properties in the reaction chamber.

Furthermore, in the embodiments shown in Fig. 1 and Fig. 2, the voltage processing module 123 preferably comprises a direct-current voltage bias sensor 125. The voltage sensor 125 has a huge equivalent resistance (e.g. $R7=1M\Omega$), wherein an input terminal is connected to an output terminal of the voltage processing module 123, and an output terminal thereof is connected to an input terminal of the testing

module 124, used for performing analog-to-digital conversion on the third voltage signal or the fourth voltage signal output by the front-end, and transmitting a converted voltage data to the testing module, for determining the plasma properties in the reaction chamber according to the converted voltage data. By firstly filtering out the alternating-current noise in the voltage of the top cover 14 through the voltage processing module 123, and then transmitting the direct-current bias voltage signal filtered out of alternating-current noise to the voltage sensor 125, the present invention can effectively avoid the interference of alternating-current noise on the voltage sensor 125, thereby improving the safety and working life of the voltage sensor 125 and the testing module 124 at the back end, and synchronously improving the accuracy of plasma properties testing results.

The working principle of the above processing apparatus for a semiconductor device and the testing system for plasma properties in a reaction chamber will be described below in conjunction with some embodiments of some testing methods for plasma properties in a reaction chamber. Those skilled in the art can understand that the embodiments of these bonding testing only provide some non-limiting implementations of the present invention, which is intended to clearly display the main idea of the present invention, and provide some specific proposals that are convenient for the public to implement, rather than limiting all working modes or all functions of the processing apparatus and the testing system. Similarly, the processing apparatus and the testing system is only a non-limiting embodiment provided by the present invention, and does not limit the implementation subject to each step in these testing methods.

Please refer to Fig. 1 to 4. Fig. 3 shows a flowchart of a testing method for plasma properties in a reaction chamber provided according to some embodiments of the present invention. Fig. 4 shows a phase curve diagram at VF1 and VF2 nodes provided according to some embodiments of the present invention.

As shown in Fig. 1 to Fig. 3, in the process of testing the plasma properties in the reaction chamber, the testing system can firstly respectively collect original voltage signals of a top cover 14 of the reaction chamber through two sampling paths 121 to 122, and then shift a voltage signal of a second sampling path 122 by 180°

through an odd number of inverting circuits 21 configured on the second sampling path 122, to obtain a second voltage signal VF2 as shown in Fig. 4. Afterwards, the testing system can use the signal superposition circuit 22 shown in Fig. 2 to add the second voltage signal to the original phase first voltage signal VF1 on the first sampling path 121 as shown in Fig. 4, to obtain a third voltage signal filtered out of alternating-current noise, and then preferably input the third voltage signal into the voltage restoration circuit 23, to obtain a fourth voltage signal with a 1/2 amplitude. Afterwards, the testing system can obtain the output third voltage signal or the fourth voltage signal through the testing module 124 at the back end, and determine the plasma properties in the reaction chamber according to the obtained third voltage signal or the fourth voltage signal.

Furthermore, in order to verify the effectiveness of the testing system for plasma properties in the reaction chamber provided by the present invention in filtering out of alternating-current noise, the present invention also conducted circuit simulations and voltage monitoring on each circuit node in the voltage processing module 123 shown in Fig. 2.

Specifically, by applying a direct-current voltage of -30V to the voltage source VG1 shown in Fig. 2 and adding alternating-current noise interference with a frequency of 50Hz and an amplitude of 100V, the actual sine wave amplitude measured at the VF1 and VF2 terminals of the voltage processing module 123 composed of the inverting circuit 21 is equal, with a phase difference of 179.51 °, and an alternating-current noise signal with an amplitude of 300mV will be measured at the VF4 terminal.

In order to further enhance the inversion capability of the voltage processing module 123 and improve the alternating-current filtering capability, in some embodiments of the present invention, at least one inverting circuit in the voltage processing module 123 can be replaced with a plurality of phase shifting circuits. The plurality of phase shifting circuits can change the phase of the voltage signal on the second sampling path 122 by a plurality of stages, for shifting the phase of the voltage signal on the second sampling path 122 by 180° by a plurality of stages, to obtain the second voltage signal.

Please refer to Fig. 5 for details, Fig. 5 shows a circuit topology diagram of a voltage processing module provided according to some embodiments of the present invention.

In the embodiment shown in Fig. 5, the voltage processing module 123 comprises two phase shifting circuits 511 to 512 and a signal superposition circuit 52. The two phase shifting circuits 511 to 512 are both 90° phase shifting circuits, for respectively shifting the phase of the voltage signal on the second sampling path 122 by 90° , to obtain the second voltage signal at the back end of the two phase shifting circuits 511 to 512. A first input terminal of the signal superposition circuit 52 is connected to an output terminal of the first sampling path 121, to obtain the first voltage signal of the original phase, and a second input terminal thereof is connected to output terminals of the two phase shifting circuits 511 to 512, to obtain the second voltage signal with an 180° phase shifting, for superimposing the first voltage signal and the second voltage signal, and outputting the third voltage signal filtered out of alternating-current noise through an output terminal thereof.

Furthermore, the voltage processing module 123 can preferably a voltage restoration circuit 53. An input terminal of the voltage restoration circuit 53 is connected to the output terminal of the signal superposition circuit 52, for obtaining the third voltage signal filtered out of alternating-current noise from the signal superposition circuit 52, and reducing it by $1/2$ to obtain a fourth voltage signal for characterizing the direct-current voltage on the top cover 14, and transmits the fourth voltage signal to the testing module 124 at the back end, for determining the plasma properties in the reaction chamber according to the fourth voltage signal.

Similarly, in order to verify the effectiveness of the testing system for the plasma properties in the reaction chamber provided by the present invention in filtering out alternating-current noise, the present invention also conducted circuit simulations and voltage monitoring on each circuit node in the voltage processing module 123 shown in Fig. 5. By applying a direct-current voltage of -30V to the voltage source VG1 shown in Fig. 5, and adding alternating-current noise interference with a frequency of 50Hz and an amplitude of 100V , the actual sine wave amplitude measured at the VF1 and VF5 terminals of the voltage processing module 123 composed of the

plurality of phase shifting circuits 511 to 512 is equal, with a phase difference of nearly 180° , and an alternating-current noise signal with an amplitude less than 1.55mV will be measured at the VF4 terminal. Therefore, the voltage processing module 123 composed of the plurality of phase shifting circuits 511 to 512 provided
5 by the present invention can achieve improved filtering effect of alternating-current noise, thereby further improving the accuracy of plasma properties testing results.

Those skilled in the art can understand, the testing system 12 shown in Fig. 1, which firstly filters out alternating-current noise in the top cover voltage through the voltage processing module 123, and then collects the direct-current bias voltage
10 filtered out of the alternating-current noise through the voltage sensor 125, is only a non-limiting embodiment provided by the disclosure, aiming to clearly demonstrate the main concept of the disclosure and provide a specific solution for public implementation, rather than limiting the scope of protection of the disclosure.

Optionally, in the embodiment shown in Fig. 6, the testing system for plasma
15 properties in a reaction chamber comprises at least two sampling paths 621 to 622, a voltage processing module 623 and a testing module 624. The at least two sampling paths 621 to 622 are used to respectively collect voltage signals of the top cover 14 of the reaction chamber. The voltage processing module 623 is connected to a second sampling path 622, for shifting a phase of the voltage signal thereof by 180° , to obtain
20 a second voltage signal. Add the second voltage signal to a first voltage signal of an original phase on a first sampling path 621, to obtain a third voltage signal filtered out of alternating-current noise. The testing module 624 is connected to the voltage processing module 623, to acquire the third voltage signal, and determine the plasma properties in the reaction chamber according to the third voltage signal.

Furthermore, the voltage processing module 623 can comprises a direct-current
25 bias voltage sensor 625 and a direct-current bias voltage sensor 626. Herein, an input terminal of the voltage sensor 625 can connect to an output terminal of the first sampling path 621, and an output terminal thereof can connect to an input terminal of the testing module 624, used for performing analog-to-digital conversion on the
30 first voltage signal, and transmitting a converted first voltage data to the testing module 624. An input terminal of the voltage sensor 626 can connect to output

terminals of the inverting circuits 21 or the plurality of phase shifting circuits 511 to 512, and an output terminal thereof can connect to the input terminal of the testing module 624, used for performing analog-to-digital conversion on the second voltage signal, and transmitting a converted second voltage data to the testing module 624.

5 Afterwards, the testing module can perform software summation on the obtained first voltage data and the second voltage data to determine a corresponding third voltage data filtered out of alternating-current noise, and determining the plasma properties in the reaction chamber according to the third voltage data, in order to avoid the need for the above-mentioned superposition circuit 22 and the restoration circuit 23,
10 thereby reducing the hardware cost of the testing system, achieving miniaturization and lightweight design, and reducing the safety risks caused by design defects in hardware devices such as circuits.

In summary, the above-mentioned testing system for plasma properties in a reaction chamber, the processing apparatus for a semiconductor device, the testing
15 method for plasma properties in a reaction chamber, and the computer-readable storage medium, which can all respectively collect the voltage of the top cover of the reaction chamber through two sampling paths, maintain the original phase of the voltage signal of one sampling path, shift the phase of the voltage signal of the other sampling path by 180 degrees, and then superimpose the output voltages of the two
20 sampling paths to filter out alternating-current noise, thereby testing the plasma properties in the reaction chamber and improving the accuracy of plasma properties testing results.

Although the method is illustrated and described as a series of actions for the purpose of simplifying the explanation, it should be understood and appreciated that
25 these methods are not limited by the order of the actions. Those skilled in the art may understand that some actions may occur in different orders and/or concurrently with other actions that are illustrated and described herein or that are not illustrated and described herein, in accordance with one or more embodiments.

The previous description of the disclosure is provided to enable any person
30 skilled in the art to make or use the disclosure. Various modifications to the present disclosure will be obvious to those skilled in the art, and the general principles defined

herein may be applied to other variations without departing from the spirit or scope of the disclosure. Thus, the present disclosure is not intended to be limited to the examples and designs described herein, but is to be accorded the broadest scope of the principles and novel features disclosed herein.

Claims

1. A testing system for plasma properties in a reaction chamber, comprising:

at least two sampling paths, used to respectively collect voltage signals of a top
5 cover of the reaction chamber, wherein the top cover is used as a radio frequency
electrode to excite plasma in the reaction chamber, and contacts an alternating-current
driven heating wire;

a voltage processing module, connected to a second sampling path, for shifting
a phase of the voltage signal thereof by 180° , to obtain a second voltage signal, and
10 adding the second voltage signal to a first voltage signal of an original phase on a first
sampling path, to obtain a third voltage signal filtered out of alternating-current noise;
and

a testing module, connected to the voltage processing module, to acquire the
third voltage signal, and determine the plasma properties in the reaction chamber
15 according to the third voltage signal.

2. The testing system according to claim 1, wherein the voltage processing
module comprises an odd number of inverting circuits, for shifting the phase of the
voltage signal on the second sampling path by 180° , to obtain the second voltage
20 signal, or

the voltage processing module comprises a plurality of phase shifting circuits,
wherein the plurality of phase shifting circuits change the phase of the voltage signal
on the second sampling path by multiple stages, for shifting the phase of the voltage
signal on the second sampling path by 180° , to obtain the second voltage signal.

3. The testing system according to claim 2, wherein the voltage processing
module comprises two phase shifting circuits, and

the two phase shifting circuits respectively shift the phase of the voltage signal
on the second sampling path by 90° , to obtain the second voltage signal.

4. The testing system according to claim 2, wherein the voltage processing module further comprises a signal superposition circuit,

a first input terminal of the signal superposition circuit is connected to an output terminal of the first sampling path, to obtain the first voltage signal of the original phase,

a second input terminal of the signal superposition circuit is connected to output terminals of the inverting circuits or the plurality of phase shifting circuits, to obtain the second voltage signal, and

an output terminal of the signal superposition circuit is connected to the testing module to output the third voltage signal filtered out of alternating-current noise.

5. The testing system according to claim 4, wherein the voltage processing module further comprises a voltage restoration circuit,

the output terminal of the signal superposition circuit is connected to the testing module through the voltage restoration circuit,

the voltage restoration circuit reduces the third voltage signal by $1/2$ to obtain a fourth voltage signal, to characterize a direct-current voltage on the top cover, and transmits the fourth voltage signal to the testing module, and

the testing module determines the plasma properties in the reaction chamber according to the fourth voltage signal.

6. The testing system according to claim 2, wherein the voltage processing module further comprises:

a first voltage sensor, wherein an input terminal of the first voltage sensor is connected to an output terminal of the voltage processing module, and an output terminal of the first voltage sensor is connected to an input terminal of the testing module, used for performing analog-to-digital conversion on the third voltage signal, and transmitting a converted third voltage data to the testing module, for determining the plasma properties in the reaction chamber according to the converted third voltage data.

7. The testing system according to claim 2, wherein the voltage processing module further comprises:

a second voltage sensor, wherein an input terminal of the second voltage sensor is connected to an output terminal of the first sampling path, and an output terminal of the second voltage sensor is connected to an input terminal of the testing module, used for performing analog-to-digital conversion on the first voltage signal, and transmitting a converted first voltage data to the testing module; and

a third voltage sensor, wherein an input terminal of the third voltage sensor is connected to output terminals of the inverting circuits or the plurality of phase shifting circuits, and an output terminal of the third voltage sensor is connected to the input terminal of the testing module, used for performing analog-to-digital conversion on the second voltage signal, and transmitting a converted second voltage data to the testing module, for the testing module summing the first voltage data and the second voltage data to determine a corresponding third voltage data, and determining the plasma properties in the reaction chamber according to the third voltage data.

8. A processing apparatus for a semiconductor device, comprising:

a reaction chamber, comprising a top cover, wherein the top cover is used as a radio frequency electrode, and contacts an alternating-current driven heating wire;

the heating wire, connected to an alternating-current driving circuit, for heating the reaction chamber to promote a vapor deposition reaction of semiconductor processing;

the testing system for plasma properties in a reaction chamber according to any one of claims 1 to 7, used for obtaining a voltage signal filtered out of alternating-current noise from the top cover, and determining the plasma properties in the reaction chamber according to the voltage signal; and

a radio frequency driving circuit, connected to the top cover and the testing system, used to drive the top cover to excite plasma in the reaction chamber according to a testing result of the plasma properties, to promote the vapor deposition reaction of semiconductor processing.

9. A testing method for plasma properties in a reaction chamber, comprising following steps:

respectively collecting voltage signals of a top cover of the reaction chamber through two sampling paths, wherein the top cover is used as a radio frequency electrode to excite plasma in the reaction chamber;

shifting a voltage signal of a second sampling path by 180° , to obtain a second voltage signal;

adding the second voltage signal to a first voltage signal of an original phase on a first sampling path, to obtain a third voltage signal filtered out of alternating-current noise; and

determining the plasma properties in the reaction chamber, according to the third voltage signal.

10. A computer-readable storage medium, storing a computer instruction thereon, wherein when the computer instruction is executed by a processor, the testing method for plasma properties in a reaction chamber according to claim 9 is implemented.