United States Patent Application Publication	20250266243
Kind Code	A1
Publication Date	August 21, 2025
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ELECTROMAGNETIC WAVE PROVIDING APPARATUS AND SUBSTRATE TREATING APPARATUS INCLUDING THE SAME

Abstract

An electromagnetic wave providing apparatus for controlling a plasma density using voltage provided to a process chamber, and a substrate treating apparatus including the same are provided. The substrate treating apparatus includes a chamber housing having an inner space defined therein for treating a substrate therein; a process gas supply unit for providing process gas into the inner space of the chamber housing; a first electrode disposed in the inner space of the chamber housing; and an electromagnetic wave providing apparatus configured to provide power to the first electrode using an electromagnetic wave, wherein the electromagnetic wave providing apparatus configured to control a plasma density generated in the inner space of the chamber housing, based on an effective value of a voltage related to the power.

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Appl. No.: **18/988208**

Filed: **December 19, 2024**

Foreign Application Priority Data

KR	10-2024-0024795	Feb. 21, 2024

Publication Classification

Int. Cl.: **H01J37/32** (20060101); **H01L21/67** (20060101)

U.S. Cl.:

CPC **H01J37/32183** (20130101); H01L21/67253 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority from Korean Patent Application No. 10-2024-0024795 filed on Feb. 21, 2024 in the Korean Intellectual Property Office, and all the benefits accruing therefrom under 35 U.S.C. 119, the contents of which in its entirety are herein incorporated by reference.

BACKGROUND

Field

[0002] The present disclosure relates to an electromagnetic wave providing apparatus applied to equipment for treating a substrate using plasma, and a substrate treating apparatus including the same.

Description of Related Art

[0003] When treating a substrate using plasma, a plasma density in an inner space of a process chamber may change due to polymer deposition occurring while the substrate is being treated. However, in order to prevent etch rates (ER) in various areas of the substrate from being different from each other while the substrate is being treated, it is necessary to maintain the plasma density in the inner space of the process chamber at a uniform level.

SUMMARY

[0004] A technical purpose to be achieved in accordance with the present disclosure is to provide an electromagnetic wave providing apparatus that controls a plasma density using a voltage provided to a process chamber, and a substrate treating apparatus including the same.

[0005] Purposes according to the present disclosure are not limited to the above-mentioned purpose. Other purposes and advantages according to the present disclosure that are not mentioned may be understood based on following descriptions, and may be more clearly understood based on embodiments according to the present disclosure. Further, it will be easily understood that the purposes and advantages according to the present disclosure may be realized using means shown in the claims and combinations thereof.

[0006] A substrate treating apparatus according to some embodiments of the present disclosure for achieving the above technical purpose incudes a chamber housing having an inner space defined therein for treating a substrate therein; a process gas supply unit for providing process gas into the inner space of the chamber housing; a first electrode disposed in the inner space of the chamber housing; and an electromagnetic wave providing apparatus configured to provide power to the first electrode using an electromagnetic wave, wherein the electromagnetic wave providing apparatus configured to control a plasma density generated in the inner space of the chamber housing, based on an effective value of a voltage related to the power.

[0007] An electromagnetic wave providing apparatus according to some embodiments of the present disclosure for achieving the above technical purpose is included in a process chamber configured to treat a substrate using plasma, and includes: a power supply configured to provide power to an electrode received in the process chamber using an electromagnetic wave; an impedance matching unit configured to perform impedance matching between the power supply and the electrode; a sensor installed on a line connecting the power supply and the electrode to each other; and a controller configured to compensate for loss of the power based on an effective value of a voltage obtained through the sensor, wherein the controller is configured to control a plasma density generated in an inner space of the process chamber based on the effective value.

[0008] A substrate treating apparatus according to some embodiments of the present disclosure for achieving the above technical purpose incudes a chamber housing having an inner space defined therein for treating a substrate therein; a process gas supply unit for providing process gas into the inner space of the chamber housing; a first electrode disposed in a lower area of the inner space of the chamber housing; a second electrode disposed in an upper area of the inner space of the chamber housing; and an electromagnetic wave providing apparatus configured to provide power to at least one of the first electrode and the second electrode using an electromagnetic wave, wherein the electromagnetic wave providing apparatus includes: a first power supply for outputting the power to the first electrode; a first sensor installed on a line connecting the first power supply and the first electrode to each other; a second power supply for outputting the power to the second electrode; a second sensor installed on a line connecting the second power supply and the second electrode to each other; and a controller configured to compensate for loss of the power, based on an effective value of a voltage obtained through at least one of the first sensor and the second sensor.
[0009] Specific details of other embodiments are included in the detailed description and drawings.

Description

BRIEF DESCRIPTION OF DRAWINGS
[0010] The above and other aspects and features of the present disclosure will become more apparent by describing in detail embodiments thereof with reference to the attached drawings, in which:
[0011] FIG. **1** is a plan view illustrating an internal structure of semiconductor manufacturing equipment according to a first embodiment;
[0012] FIG. **2** is a plan view illustrating an internal structure of semiconductor manufacturing equipment according to a second embodiment;
[0013] FIG. **3** is a plan view illustrating an internal structure of semiconductor manufacturing equipment according to a third embodiment;
[0014] FIG. **4** is a cross-sectional view illustrating an internal structure of a substrate treating apparatus according to a first embodiment;
[0015] FIG. **5** is a cross-sectional view illustrating an internal structure of a substrate treating apparatus according to a second embodiment;
[0016] FIG. **6** is a cross-sectional view illustrating an internal structure of a substrate treating apparatus according to a third embodiment;
[0017] FIG. **7** is an example diagram for illustrating an electromagnetic wave providing apparatus according to a first embodiment of the present disclosure.
[0018] FIG. **8** is an example diagram for illustrating a first impedance matching unit constituting the electromagnetic wave providing apparatus according to the first embodiment of the present disclosure;
[0019] FIG. **9** is an example diagram for illustrating a first sensor constituting the electromagnetic wave providing apparatus according to the first embodiment of the present disclosure;
[0020] FIG. **10** is a first flowchart for illustrating an operation method of a controller constituting the electromagnetic wave providing apparatus according to the first embodiment of the present disclosure;
[0021] FIG. **11** is a second flowchart for illustrating an operation method of a controller constituting the electromagnetic wave providing apparatus according to the first embodiment of the present disclosure;
[0022] FIG. **12** is an example diagram for illustrating an electromagnetic wave providing apparatus according to a second embodiment of the present disclosure;

[0023] FIG. **13** is an example diagram for illustrating an electromagnetic wave providing apparatus according to a third embodiment of the present disclosure; and

[0024] FIG. **14** is a flowchart for illustrating an impedance control method in the substrate treating apparatus by the electromagnetic wave providing apparatus according to the first embodiment of the present disclosure.

DETAILED DESCRIPTIONS

[0025] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the attached drawings. Identical reference numerals are used for identical components in the drawings, and redundant descriptions thereof are omitted.

[0026] The present disclosure relates to a substrate treating apparatus that treats a substrate using plasma and to semiconductor manufacturing equipment including a plurality of substrate treating apparatuses. The substrate treating apparatus may include an electromagnetic wave providing apparatus that provides an RF radio frequency signal to a process chamber to generate the plasma therein. The electromagnetic wave providing apparatus may control a plasma density in real time by changing a power provided to the process chamber.

[0027] Hereinafter, the substrate treating apparatus and the semiconductor manufacturing equipment including the same will be described first, and then the electromagnetic wave providing apparatus will be described.

[0028] FIG. **1** is a plan view showing an example of an internal structure of semiconductor manufacturing equipment according to a first embodiment. FIG. **2** is a plan view showing an example of an internal structure of semiconductor manufacturing equipment according to a second embodiment. FIG. **3** is a plan view showing an example of an internal structure of semiconductor manufacturing equipment according to a third embodiment.

[0029] A first direction D**1** and a second direction D**2** define a plane in a horizontal direction.

[0030] For example, the first direction D**1** may be a front-back direction, and the second direction D**2** may be a left-right direction. Alternatively, the first direction D**1** may be the left-right direction, and the second direction D**2** may be the front-back direction. The third direction D**3** may be a height direction, and is a direction perpendicular to the plane defined by the first direction D**1** and the second direction D**2**. The third direction D**3** may be a vertical direction.

[0031] According to FIGS. **1** to **3**, semiconductor manufacturing equipment **100** may be configured to include a load port module **110**, an index module **120**, a load lock chamber **130**, a transfer module **140**, and a process chamber **150**

[0032] The semiconductor manufacturing equipment **100** is a system that processes a substrate using an etching process, a cleaning process, a deposition process, etc. The semiconductor manufacturing equipment **100** may include one process chamber. However, embodiments of the present disclosure are not limited thereto, and the semiconductor manufacturing equipment **100** may include a plurality of process chambers. The plurality of process chambers may include process chambers of the same type. However, embodiments of the present disclosure are not limited thereto, and the plurality of process chambers may include process chambers of different types. In a case where the semiconductor manufacturing equipment **100** includes the plurality of process chambers, the semiconductor manufacturing equipment **100** may be embodied as a multi-chamber type substrate treating system.

[0033] The load port module **110** is configured such that a container SC containing therein a plurality of substrates may be seated thereon. In this regard, the container SC may be, for example, a FOUP (Front Opening Unified Pod).

[0034] The container SC may be loaded or unloaded into or out of the load port module **110**. Furthermore, in the load port module **110**, the substrate stored in the container SC may be loaded or unloaded into or therefrom.

[0035] When a loading or unloading target is the container SC, a container transport apparatus may load or unload the container SC to or out of the load port module **110**. Although not shown in FIG.

1 to FIG. **3**, the container transport apparatus may be an OHT (Overhead Hoist Transporter). When the loading or unloading target is the substrate, a first conveying robot **122** may load or unload the substrate into or out of the container SC seated on the load port module **110**.
[0036] The load port modules **110** may be respectively positioned at multiple positions and may be disposed in front of the index module **120**. For example, three load port modules **110**_a_, **110**_b_, and **110**_c_, including the first load port module **110**_a_, the second load port module **110**_b_, and the third load port module **110**_c_, may be disposed in front of the index module **120**.
[0037] When the load port modules **110** are positioned at the multiple positions, respectively, and in front of the index module **120**, the containers SC respectively seated on the load port modules may contain different types of objects, respectively. For example, a first container SC**1** seated on the first load port module **110**_a_ may contain a wafer-type sensor. A second container SC**2** seated on the second load port module **110**_b_ may contain a substrate, i.e., a wafer. A third container SC**3** seated on the third load port module **110**_c_ may contain a consumable part such as a focus ring and an edge ring.
[0038] However, the present embodiment is not limited thereto. The containers SC respectively seated on the different load port modules may contain objects of the same type, respectively. Alternatively, the containers seated on some load port modules among the plurality of load port modules may contain objects of the same type, respectively, while the containers seated on the other load port modules among the plurality of load port modules may contain objects of different types, respectively.
[0039] The index module **120** may be disposed between the load port module **110** and the load lock chamber **130**, and may be embodied as an interface so that a substrate may be transferred between the container SC on the load port module **110** and the load lock chamber **130** through the interface.
[0040] The index module **120** may include a first module housing **121** and the first conveying robot **122**. The first conveying robot **122** may be disposed inside the first module housing **121**, and may convey the substrate between the load port module **110** and the load lock chamber **130**. The first module housing **121** may have an internal environment as an atmospheric pressure environment created therein, and the first conveying robot **122** may operate in the atmospheric pressure environment. A single first conveying robot **122** may be included in the first module housing **121**. However, embodiments of the present disclosure are not limited thereto, and a plurality of first conveying robots **122** may be included in the first module housing **121**.
[0041] In this embodiment, a front end module (FEM) may be disposed on one side of the load lock chamber **130**. The front end module (FEM) may include the load port module **110** and the index module **120**, and may be embodied as an Equipment Front End Module (EFEM) in one example.
[0042] The load lock chamber **130** may function as a buffer chamber between an input port and an output port in the semiconductor manufacturing equipment **100**. That is, the load lock chamber **130** may temporarily store therein an untreated substrate or a treated substrate while being disposed between the load port module **110** and the process chamber **150**. Although not shown in FIGS. **1** to **3**, the load lock chamber **130** may include a buffer stage that temporarily stores the substrate therein.
[0043] A plurality of load lock chambers **130** may be disposed between the index module **120** and the transfer module **140**. For example, two load lock chambers **130**_a_ and **130**_b_, such as a first load lock chamber **130**_a_ and a second load lock chamber **130**_b_, may be disposed between the index module **120** and the transfer module **140**.
[0044] Among the first load lock chamber **130**_a_ and the second load lock chamber **130**_b_, one load lock chamber may temporarily store therein an untreated substrate to be conveyed from the index module **120** to the transfer module **140**. The other load lock chamber among the first load lock chamber **130**_a_ and the second load lock chamber **130**_b_ may temporarily store therein a treated substrate to be conveyed from the transfer module **140** to the index module **120**. However, the

present disclosure is not limited thereto, and each of the first load lock chamber **130***a* and the second load lock chamber **130***b* may perform both the role of temporarily storing therein the untreated substrate and the role of temporarily storing therein the treated substrate.

[0045] The load lock chamber **130** may change an inner space thereof into either a vacuum environment or an atmospheric pressure environment using a gate valve, etc. In detail, when the first conveying robot **122** of the index module **120** loads the substrate into the load lock chamber **130** or the first conveying robot **122** unloads the substrate from the load lock chamber **130**, the load lock chamber **130** may change the inner space thereof into an environment identical to or similar to the internal environment of the index module **120**. Furthermore, when the second conveying robot **142** of the transfer module **140** loads the substrate into the load lock chamber **130** or the second conveying robot **142** unloads the substrate from the load lock chamber **130**, the load lock chamber **130** may change the inner space thereof into an environment identical or similar to the internal environment of the transfer module **140**. Thus, the load lock chamber **130** may prevent the internal pressure state of the index module **120** or the internal pressure state of the transfer module **140** from changing.

[0046] The transfer module **140** may be disposed between the load lock chamber **130** and the process chamber **150**, and may be embodied as an interface so that the substrate may be transferred between the load lock chamber **130** and the process chamber **150** through the interface.

[0047] The transfer module **140** may include a second module housing **141** and the second conveying robot **142**. The second conveying robot **142** may be disposed inside the second module housing **141** and may convey the substrate between the load lock chamber **130** and the process chamber **150**. The second module housing **141** may have a vacuum environment as an internal environment thereof, and the second conveying robot **142** may operate in the vacuum environment. A single second conveying robot **142** may be provided in the second module housing **141**. However, embodiments of the present disclosure are not limited thereto and a plurality of second conveying robots **142** may be provided in the second module housing **141**.

[0048] The transfer module **140** may be connected to the plurality of process chambers **150**. For this purpose, the second module housing **141** may include a plurality of sides, and the second conveying robot **142** may be configured to freely pivot around each of the sides of the second module housing **141** so that the second conveying robot **142** may load the substrate into each of the plurality of process chambers **150** or unload the substrate from each of the plurality of process chambers **150**.

[0049] The process chamber **150** serves to treat the substrate. The process chamber **150** may treat the substrate when an untreated substrate has been provided thereto, and may provide the treated substrate to the load lock chamber **130** through the transfer module **140**. A more detailed description of the process chamber **150** will be set forth later.

[0050] When the semiconductor manufacturing equipment **100** includes the plurality of process chambers, the semiconductor manufacturing equipment **100** may be formed as a structure having a cluster platform. For example, the plurality of process chambers may be arranged in a cluster manner around the transfer module **140** as shown in the example of FIG. **1**. However, the present embodiment is not limited thereto. In the case where the semiconductor manufacturing equipment **100** includes the plurality of process chambers, the semiconductor manufacturing equipment **100** may be formed as a structure having a quad platform. For example, the plurality of process chambers may be arranged in a quad manner around the transfer module **140** as shown in the example of FIG. **2**. Alternatively, in the case where the semiconductor manufacturing equipment **100** includes the plurality of process chambers, the semiconductor manufacturing equipment **100** may be formed as a structure having an in-line platform. For example, the plurality of process chambers may be arranged in an in-line manner around the transfer module **140** as shown in the example of FIG. **3**, in which two arrangements of the process chambers may be respectively disposed on both opposing sides of the transfer module **140**, and the different process chambers in the two arrangements may face each other in a corresponding manner with each other, and each of the two arrangements may extend in a line.

[0051] Although not shown in FIG. **1** to FIG. **3**, the semiconductor manufacturing equipment **100** may further include a control device. The control device is configured to control an operation of each of the modules constituting the semiconductor manufacturing equipment **100**. For example, the control device may be configured to control the substrate convey of the first conveying robot **122** or the second conveying robot **142**, control the internal environmental change of the load lock chamber **130**, and control the overall substrate treating process of the process chamber **150**

[0052] The control device may include a processor that executes control of each of the components constituting the semiconductor manufacturing equipment **100**, a network over which the components communicate with each other in a wired manner or wirelessly, one or more instructions related to a function or an operation for controlling each of the components, a memory means that stores therein treating recipes including instructions, various data, etc. The control device may further include a user interface including an input means for an operator to perform command input manipulation, etc. to manage the semiconductor manufacturing equipment **100**, and an output means for visualizing and displaying the operating status of the semiconductor manufacturing equipment **100**. The control device may be embodied as a computing device for data processing and analysis, command transmission, etc.

[0053] The instructions may be provided in a form of a computer program or an application. The computer program may be stored in a computer-readable recording medium containing one or more instructions. The instructions may include codes generated by a compiler, codes that may be executed by an interpreter, etc. The memory means may be embodied as one or more storage media selected from flash memory, HDD, SSD, card type memory, RAM, SRAM, ROM, EEPROM, PROM, magnetic memory, magnetic disk, and optical disk.

[0054] Next, the process chamber **150** is described. The plurality of process chambers **150** may be disposed within the semiconductor manufacturing equipment **100**, and the plurality of process chambers may be arranged around the transfer module **140** so as to be spaced apart from each other. However, the present disclosure is not limited thereto, and a single process chamber **150** may be provided in within the semiconductor manufacturing equipment **100**. The process chamber **150** may treat the substrate. Hereinafter, the process chamber **150** will be defined as a substrate treating apparatus, and an internal structure thereof will be described.

[0055] FIG. **4** is a cross-sectional view showing an example of an internal structure of the substrate treating apparatus according to a first embodiment. A substrate treating apparatus **200** may treat a substrate W using plasma. The substrate treating apparatus **200** may treat a substrate W in a dry manner.

[0056] The substrate treating apparatus **200** may treat a substrate W in a vacuum environment. According to FIG. **4**, the substrate treating apparatus **200** may be configured to include a chamber housing CH, a substrate support unit **210**, a cleaning gas supply unit **220**, a process gas supply unit **230**, a showerhead unit **240**, a plasma generation unit **250**, a liner unit **260**, a baffle unit **270**, a window module WM, and an antenna unit **280**.

[0057] The chamber housing CH provides a space where a process for treating the substrate W using plasma, i.e., a plasma process, is performed. The chamber housing CH may be made of alumite having an anodic oxide film formed on its surface, and an inner space thereof may be configured to be airtight. The chamber housing CH may be provided in a cylindrical shape. However, embodiments of the present disclosure are not limited thereto and the chamber housing CH may be provided in other shapes. The chamber housing CH may have an exhaust hole **201** defined in a bottom thereof.

[0058] The exhaust hole **201** may be connected to an exhaust line **203** equipped with a pump **202**. The exhaust hole **201** may discharge process byproducts generated during the plasma process and gases remaining inside the chamber housing CH to the outside out of the chamber housing CH through the exhaust line **203**. In this case, the inner space of the chamber housing CH may be depressurized

[0059] An opening **204** may extend through a side wall of the chamber housing CH. The opening **204** may act as a passage through which the substrate W enters and exits the inside of the chamber housing CH. The opening **204** may be configured to be automatically opened and closed by, for example, a door assembly **205**.

[0060] The door assembly **205** may be configured to include an outer door **206** and a door driver **207**. The outer door **206** may open and close the opening **204** while being disposed on an outer wall of the chamber housing CH. The outer door **206** may be moved in the height direction D**3** of the substrate treating apparatus **200** under control of the door driver **207**. The door driver **207** may operate using at least one element selected from a motor, a hydraulic cylinder, and a pneumatic cylinder.

[0061] The substrate support unit **210** is installed in a lower area of the inner space of the chamber housing CH. The substrate support unit **210** may absorb and support the substrate W using an electrostatic force. For example, the substrate support unit **210** may be embodied as an electrostatic chuck (ESC). However, the present disclosure is not limited thereto, and the substrate support unit **210** may support the substrate W thereon using various other schemes such as vacuum, mechanical clamping, etc.

[0062] When the substrate support unit **210** is embodied as the electrostatic chuck (ESC), the substrate support unit **210** may be configured to include a base plate **211** and a dielectric layer **212**. The dielectric layer **212** may be disposed on the base plate **211** and may adsorb and support the substrate W that is placed thereon. The base plate **211** may be made of a material having excellent corrosion resistance and heat resistance. The base plate **211** may be embodied as an aluminum body, for example. The dielectric layer **212** may be made of a ceramic material, for example, and may be embodied as a ceramic puck.

[0063] Although not shown in FIG. **4**, the substrate support unit **210** may be configured to further include a bonding layer. The bonding layer may bond the base plate **211** and the dielectric layer **212** to each other. The bonding layer may include, for example, a polymer.

[0064] A ring structure **213** is provided to surround an outer edge area of the dielectric layer **212**. The ring structure **213** may play a role in concentrating ions on the substrate W when the plasma process is performed inside the chamber housing CH. The ring structure **213** may be made of silicon. The ring structure **213** may be embodied, for example, as a focus ring.

[0065] Although not shown in FIG. **4**, the ring structure **213** may further include an edge ring. The edge ring may be provided under or an outer side of a focus ring. The edge ring may play a role in preventing a side surface of the dielectric layer **212** from being damaged by plasma. The edge ring may be made of an insulating material, for example, ceramic or quartz.

[0066] A heating member **214** and a cooling member **215** are provided to maintain the substrate W at a process temperature when the substrate treating process is performed inside the chamber housing CH. The heating member **214** may be installed inside the dielectric layer **212** and may be embodied as a heating wire. The cooling member **215** may be installed inside the base plate **211** and may be embodied as a cooling pipe through which a coolant flows. A cooling device or a chiller **216** may supply the coolant to the cooling member **215**. The cooling device **216** may use cooling water as the coolant. However, embodiments of the present disclosure are not limited thereto and helium (He) gas may be used as the coolant. Alternatively, the cooling device **216** may use both the cooling water and helium gas as the coolant. In one example, the heating member **214** may not be disposed inside the substrate support unit **210**.

[0067] The cleaning gas supply unit **220** provides a cleaning gas onto the dielectric layer **212** or the ring structure **213** to remove foreign substances remaining on the dielectric layer **212** or the ring structure **213**. For example, the cleaning gas supply unit **220** may provide nitrogen (N_2) gas as the cleaning gas.

[0068] The cleaning gas supply unit **220** may include a cleaning gas supply source **221** and a cleaning gas supply pipe **222**. The cleaning gas supply pipe **222** may be connected to a space between the dielectric layer **212** and the ring structure **213**. The cleaning gas supplied from the cleaning gas supply source **221** may flow to the space between the dielectric layer **212** and the ring structure **213** through the cleaning gas supply pipe **222** to remove the foreign substances remaining on an edge portion of the dielectric layer **212** or an upper portion of the ring structure **213**.
[0069] The process gas supply unit **230** provides process gas to the inner space of the chamber housing CH. The process gas supply unit **230** may provide process gas to the inner space of the chamber housing CH through a hole extending through an upper cover, that is, the window module WM of the chamber housing CH. However, the present disclosure is not limited thereto, and the process gas supply unit **230** may provide the process gas to the inner space of the chamber housing CH through a hole extending through a side wall of the chamber housing CH.
[0070] The process gas supply unit **230** may include a process gas supply source **231** and a process gas supply pipe **232**. The process gas supply source **231** may provide gas used to treat the substrate W as the process gas.
[0071] The showerhead unit **240** sprays the process gas provided from the process gas supply source **231** to an entire area of the substrate W placed in the inner space of the chamber housing CH. The showerhead unit **240** may be connected to the process gas supply source **231** via the process gas supply pipe **232**.
[0072] The showerhead unit **240** may be disposed in the inner space of the chamber housing CH and may include a showerhead body **241** and a plurality of gas feeding holes **242**. The showerhead body **241** may be made of silicon. However, embodiments of the present disclosure are not limited thereto and the showerhead body **241** may be made of metal. The plurality of gas feeding holes **242** may extend through a surface of the showerhead body **241** in the vertical direction D**3**. The plurality of gas feeding holes **242** may be spaced apart from each other by a predetermined spacing and may extend through the showerhead body **241**. The plurality of gas feeding holes **242** may uniformly inject the process gas to the entire area of the substrate W.
[0073] Although not shown in FIG. **4**, the showerhead body **241** may be divided into a plurality of modules. For example, the showerhead body **241** may be divided into a first head module, a second head module, and a third head module. The first head module may be disposed at a position corresponding to or overlapping a center area of the substrate W. The second head module may be disposed to surround an outer edge of the first head module. The second head module may be disposed at a position corresponding to or overlapping a middle area of the substrate W. The third head module may be disposed to surround an outer edge of the second head module. The third head module may be disposed at a position corresponding to or overlapping an edge area of the substrate W.
[0074] The plasma generation unit **250** generates plasma from gas remaining in a discharge space. In this regard, the discharge space may be embodied as a portion of the inner space of the chamber housing CH defined between the showerhead unit **240** and the window module WM. Alternatively, the discharge space may be a space defined between the substrate support unit **210** and the showerhead unit **240**. When the discharge space is a space defined between the substrate support unit **210** and the showerhead unit **240**, the discharge space may be divided into a plasma area and a process area. The plasma area may be positioned on top of the process area.
[0075] The plasma generation unit **250** may generate the plasma in the discharge space using an ICP (Inductively Coupled Plasma) source. For example, the plasma generation unit **250** may generate the plasma in the discharge space using the substrate support unit **210** and the antenna unit **280** as a first electrode (lower electrode) and a second electrode (upper electrode), respectively.
[0076] However, the present embodiment is not limited thereto. The plasma generation unit **250** may generate the plasma in the discharge space using a CCP (Capacitively Coupled Plasma) source. For example, the plasma generation unit **250** may generate the plasma in the discharge

space using the substrate support unit **210** and the showerhead unit **240** as the first electrode (lower electrode) and the second electrode (upper electrode), respectively. Frist, a case where the plasma generation unit **250** is embodied using the ICP source will be described, and then, a case where the plasma generation unit **250** is embodied using the CCP source will be described.

[0077] The plasma generation unit **250** may be configured to include a first high-frequency power source **251**, a first connection line **252**, a second high-frequency power source **253**, and a second connection line **254**.

[0078] The first high-frequency power source **251** may apply the RF power to the first electrode. The first high-frequency power source **251** may serve as a plasma source that generates plasma within the chamber housing CH. However, the present disclosure is not limited thereto. The first high-frequency power source **251** together with the second high-frequency power source **253** may serve to control the characteristics of the plasma within the chamber housing CH.

[0079] The first high-frequency power source **251** may include a plurality of first high-frequency power sources included within the substrate treating apparatus **200**. In this case, the plasma generation unit **250** may include a first matching network electrically connected to each of the first high-frequency power sources. When frequency powers of different magnitudes are input from the plurality of first high-frequency power sources thereto, the first matching network may serve to match the frequency powers of different magnitudes with each other and apply the matching result to the first electrode.

[0080] The first connection line **252** may connect the first electrode to GND. The first high-frequency power source **251** may be installed on the first connection line **252**. However, the present disclosure is not limited thereto, and the first connection line **252** may connect the first electrode and the first high-frequency power source **251** to each other. For example, the first connection line **252** may be embodied as an RF rod.

[0081] The second high-frequency power source **253** applies the RF power to the second electrode. The second high-frequency power source **253** may play a role in controlling the characteristics of the plasma within the chamber housing CH. For example, the second high-frequency power source **253** may play a role in controlling ion bombardment energy within the chamber housing CH.

[0082] The second high-frequency power source **253** may include a plurality of second high-frequency power sources included within the substrate treating apparatus **200**. In this case, the plasma generation unit **250** may include a second matching network electrically connected to each of the second high-frequency power sources. When frequency powers of different magnitudes are input from the plurality of second high-frequency power sources thereto, the second matching network may play a role of matching the frequency powers of different magnitudes with each other and applying the matching result to the second electrode.

[0083] The second connection line **254** connects the second electrode to GND. The second high-frequency power source **253** may be installed on the second connection line **254**.

[0084] The liner unit **260** is also defined as a wall liner and protects the inside of the chamber housing CH from arc discharge generated during the process of exciting the process gas or impurities generated during the substrate treating process. The liner unit **260** may be formed to cover an inner wall of the chamber housing CH.

[0085] The baffle unit **270** plays a role of exhausting process byproducts or unreacted gases of the plasma inside the chamber housing CH to the outside. The baffle unit **270** may be installed in the space between the substrate support unit **210** and the inner wall (or the liner unit **260**) of the chamber housing CH, and may be installed adjacent to the exhaust hole **201**. The baffle unit **270** may be provided in an annular ring shape and may be disposed between the substrate support unit **210** and the inner wall of the chamber housing CH.

[0086] The baffle unit **270** may include a plurality of slot holes extending through the body in the vertical direction D**3** to control flow of the process gas within the chamber housing CH. The baffle unit **270** may be made of a material having etching resistance to minimize damage thereto or deformation thereof by radicals, etc. in the inner space of the chamber housing CH where the plasma is generated. For example, the baffle unit **270** may include quartz.

[0087] The window module WM serves as the upper cover of the chamber housing CH that seals the inner space of the chamber housing CH. The window module WM may be configured to be removable from the chamber housing CH. However, embodiments of the present disclosure are not limited thereto, and the window module WM may be integral with the chamber housing CH. The window module WM may be formed as a dielectric window made of an insulating material. For example, the window module WM may be made of alumina. The window module WM may include a coating film on a surface thereof to suppress the generation of particles when the plasma process is performed in the inner space of the chamber housing CH.

[0088] The antenna unit **280** generates a magnetic field and an electric field inside the chamber housing CH to excite the process gas into plasma. The antenna unit **280** may operate using the RF power supplied from the second high-frequency power source **253**. The antenna unit **280** may be disposed on top of the chamber housing CH. For example, the antenna unit **280** may be disposed on the window module WM. However, the present disclosure is not limited thereto, and the antenna unit **280** may be disposed on the side wall of the chamber housing CH.

[0089] The antenna unit **280** may include a body **281**, and an antenna **282** inside or on a surface of the body **281**. The antenna **282** may be formed in a closed loop shape using a coil. The antenna **282** may be formed in a spiral shape or other various shapes along a width direction D**1** of the chamber housing CH.

[0090] The antenna unit **280** may be formed to have a planar structure. However, the present disclosure is not limited thereto, and the antenna unit **280** may be formed to have a cylindrical structure. When the antenna unit **280** is formed to have the planar structure, the antennal unit may be disposed on top of the chamber housing CH. When the antenna unit **280** is formed to have the cylindrical structure, the antenna unit **280** may be disposed to surround the outer wall of the chamber housing CH.

[0091] Referring to FIG. **4**, a case where the plasma generation unit **250** may be embodied using the ICP source has been described above. Hereinafter, referring to FIG. **5** and FIG. **6**, the case where the plasma generation unit **250** is embodied using the CCP source will be described. Hereinafter, the description of duplicate contents with those of the case of FIG. **4** will be omitted, and only differences therebetween will be described.

[0092] FIG. **5** is a cross-sectional view showing an example of an internal structure of a substrate treating apparatus according to a second embodiment. FIG. **6** is a cross-sectional view showing an example of an internal structure of a substrate treating apparatus according to a third embodiment.

[0093] According to FIG. **5** and FIG. **6**, the substrate treating apparatus **200** may be configured to include a chamber housing CH, a substrate support unit **210**, a cleaning gas supply unit **220**, a process gas supply unit **230**, a showerhead unit **240**, a plasma generation unit **250**, a liner unit **260**, a baffle unit **270**, and a window module WM.

[0094] That is, the substrate treating apparatus **200** of FIG. **5** and FIG. **6** may not include the antenna unit **280** compared to the substrate treating apparatus **200** of FIG. **4**.

[0095] The plasma generation unit **250** may be configured to include the first high-frequency power source **251**, the first connection line **252**, the second high-frequency power source **253**, and the second connection line **254** as shown in FIG. **5**. However, the present disclosure is not limited thereto, and the plasma generation unit **250** may be configured to include the first high-frequency power source **251**, the first connection line **252**, and the second connection line **254** as shown in FIG. **6**. That is, the plasma generation unit **250** of FIG. **6** may not include the second high-frequency power source **253** compared to the plasma generation unit **250** of FIG. **5**.

[0096] In the example according to FIG. **4**, the second connection line **254** may be connected to the antenna **282** of the antenna unit **280**. The second high-frequency power source **253** may apply the RF power to the antenna **282** of the antenna unit **280**. In the example according to FIG. **5**, the second connection line **254** may be connected to the showerhead body **241**. The second high-frequency power source **253** may apply the RF power to the showerhead body **241**.

[0097] In the example according to FIG. **5**, the second high frequency power source **253** may be installed on the second connection line **254**. In the example according to FIG. **6**, the second high frequency power source **253** may not be installed on the second connection line **254**. When the second high frequency power source **253** is installed on the second connection line **254**, the plasma generation unit **250** may apply multi-frequency to the substrate treating apparatus **200**.

[0098] The plasma generation unit **250** may generate the plasma in the inner space of the chamber housing CH to treat the substrate W. The plasma generation unit **250** may generate the plasma using the upper electrode and the lower electrode that are disposed in the inner space of the chamber housing CH or out thereof.

[0099] The plasma generation unit **250** may include the electromagnetic wave providing apparatus to generate the plasma. The electromagnetic wave providing apparatus may provide an electromagnetic wave to the inner space of the chamber housing CH.

[0100] FIG. **7** is an example diagram for illustrating an electromagnetic wave providing apparatus according to a first embodiment of the present disclosure. Referring to FIG. **7**, an electromagnetic wave providing apparatus **300** may be configured to include a first power supply **310**, a first impedance matching unit **320**, a first sensor **330**, and a controller **340**.

[0101] The electromagnetic wave providing apparatus **300** may provide the power to a first electrode **410** using an electromagnetic wave. When the power is provided to the first electrode **410** through the electromagnetic wave providing apparatus **300**, the first electrode **410** may generate the plasma in the inner space of the chamber housing CH using the process gas. The first electrode **410** may be placed in the inner space of the chamber housing CH. The first electrode **410** may be the lower electrode in the substrate treating apparatus **200**. For example, the first electrode **410** may be the substrate support unit **210** embodied as the electrostatic chuck (ESC).

[0102] The first power supply **310** may output power to the first electrode **410**. The power provided from the first power supply **310** may be transmitted to the first electrode **410** via the first impedance matching unit **320**. The first power supply **310** and the first impedance matching unit **320** may be interconnected to each other via the first transmission line **350**.

[0103] The first power supply **310** may provide the power to the first electrode **410** using an RF signal. The first power supply **310** may provide the power to the first electrode **410** using a high-frequency signal. Referring to FIGS. **4** to **6**, the first power supply **310** may be embodied as the first high-frequency power source **251** included in the substrate treating apparatus **200**.

[0104] The first power supply **310** may include a plurality of power modules. For example, the first power supply **310** may include a first power module **310***a*, a second power module **310***b*, and a third power module **310***c*. The first power module **310***a*, the second power module **310***b*, and the third power module **310***c* may be connected in parallel with each other and may be connected to the first impedance matching unit **320**. The following description will be based on an example where the first power supply **310** is composed of three power modules **310***a*, **310***b*, and **310***c*. However, the number of power modules in this embodiment is not limited thereto.

[0105] The first impedance matching unit **320** is configured to perform impedance matching between the first power supply **310** and the first electrode **410**. The first impedance matching unit **320** may enable the RF signal provided from the first power supply **310** to be transmitted to the first electrode **410** without loss. The first impedance matching unit **320** may cancel a reactance term to enable the RF signal to be transmitted completely thereto.

[0106] The first power module **310***a*, the second power module **310***b*, and the third power module **310***c* may apply frequency power having the same magnitude. However, the present disclosure is not limited thereto, and the first power module **310***a*, the second power module **310***b*, and the third power module **310***c* may apply frequency powers having different magnitudes. When the first power module **310***a*, the second power module **310***b*, and the third power module **310***c* apply frequency powers of different magnitudes, the first impedance matching unit **320** may play a role of matching the frequency powers of different magnitudes respectively applied from the first power module **310***a*, the second power module **310***b*, and the third power module **310***c* with each other and providing the matching result to the first electrode **410**. The first impedance matching unit **320** may not be included in the electromagnetic wave providing apparatus **300**.

[0107] FIG. **8** is an example diagram for illustrating the first impedance matching unit constituting the electromagnetic wave providing apparatus according to the first embodiment of the present disclosure. Referring to FIG. **8**, the first impedance matching unit **320** may be configured to include a first capacitor **510**, a second capacitor **520**, and a first coil **530**.

[0108] The first impedance matching unit **320** may electrically connect each of the power modules **310***a*, **310***b*, and **310***c* to the first sensor **330** using a fourth transmission line **540**. The power modules **310***a*, **310***b*, and **310***c* may be connected in a parallel manner with each other and a parallel combination thereof may be connected to the first sensor **330** in series manner via the fourth transmission line **540**. The first capacitor **510** and the first coil **530** may be disposed on the fourth transmission line **540**.

[0109] The first capacitor **510** and the first coil **530** may be connected in series to each other and may be disposed on the fourth transmission line **540**. The first capacitor **510** may be disposed closer to the first sensor **330** than the first coil **530** may be. The first coil **530** may be disposed closer to a combination of the power modules **310***a*, **310***b*, and **310***c* than the first capacitor **510** may be.

[0110] The first impedance matching unit **320** may include a fifth transmission line **550** branched from the fourth transmission line **540**. The fifth transmission line **550** may be connected to a ground GND. The second capacitor **520** may be disposed on the fifth transmission line **550**. The fifth transmission line **550** may be branched from a portion of the fourth transmission line **540** connecting the combination of the power module **310***a*, **310***b*, and **310***c* to the first coil **520**.

[0111] Description will be made with reference back to FIG. **7**.

[0112] The first sensor **330** may be disposed between the first impedance matching unit **320** and the first electrode **410**. The first sensor **330** and the first impedance matching unit **320** may be electrically connected to each other using a second transmission line **360**. The first sensor **330** and the first electrode **410** may be electrically connected to each other using a third transmission line **370**.

[0113] The first sensor **330** may measure the power value applied from each of the power modules **310***a*, **310***b*, and **310***c* to the first electrode **410**. While treating the substrate W, particles such as polymers may be generated from the substrate W. Then, the particles detached from the substrate W may not be removed and may be deposited on parts within the substrate treating apparatus **200**. That is, the internal environment of the chamber housing CH may change due to the particles such as the polymer while treating the substrate W.

[0114] When the internal environment of the chamber housing CH changes, the plasma density within the chamber housing CH may change. The power applied to the first electrode **410** from each of the power modules **310***a*, **310***b*, and **310***c* may be adjusted such that the change in the plasma density may be controlled. For example, when the plasma density has decreased due to the change in the internal environment of the chamber housing CH, the power applied to the first electrode **410** may be increased to compensate for the decrease in the plasma density.

[0115] An ideal value of the power applied to the first electrode **410** from each of the power modules **310***a*, **310***b*, and **310***c* may be calculated based on a value of the power output from each of the power modules **310***a*, **310***b*, and **310***c*. However, the ideal value of the power may be subjected to loss on a path along which the power is applied to the first electrode **410** from each of the power modules **310***a*, **310***b*, and **310***c*. As a result, there may be a difference from the ideal value and an actual value of the power absorbed into the plasma after the power is applied to the first electrode **410**.

[0116] The plasma density within the chamber housing CH is related to the power absorbed by the plasma. The power absorbed by the plasma is proportional to an effective value V.sub.rms of a voltage applied to the first electrode **410**. Using the first sensor **330**, the effective value of the voltage applied from each of the power modules **310***a*, **310***b*, and **310***c* to the first electrode **410** may be calculated. Using the first sensor **330**, the effective value of the voltage may be calculated in real time. The controller **340** may be configured to adjust the power absorbed by the plasma within the chamber housing CH in real time based on the effective value of the voltage calculated through the first sensor **330**, and may control the plasma density within the chamber housing CH in real time.
[0117] FIG. **9** is an example diagram for illustrating the first sensor constituting the electromagnetic wave providing apparatus according to the first embodiment of the present disclosure. Referring to FIG. **9**, the first sensor **330** may be configured to include a rod **560** and a second coil **570**.
[0118] The rod **560** may carry current. The rod **560** may carry the current so that the power may be applied to the first electrode **410**. The rod **560** may be made of a material through which current may be conductive. For example, the rod **560** may be made of a metal material. The rod **560** may be connected to the second transmission line **360** and the third transmission line **370**. One end of the rod **560** may be connected to the second transmission line **360**, and the other end of the rod **560** may be connected to the third transmission line **370**.
[0119] The second coil **570** may be formed to surround an outer surface of the rod **560**. The second coil **570** may be formed to surround an entirety of the outer surface of the rod **560**. However, the present disclosure is not limited thereto, and the second coil **570** may be formed to surround a portion of the outer surface of the rod **560**. When the second coil **570** is formed to surround the outer surface of the rod **560** through which the current flows, a magnetic field may be induced around the second coil **570**. In this embodiment, the effective value of the voltage may be calculated based on an intensity of the magnetic field.
[0120] Each of the second transmission line **360** and the third transmission line **370** may be made of the same material as that of the rod **560**. For example, each of the second transmission line **360**, the rod **560**, and the third transmission line **370** may be embodied as a RF rod. The RF rod may interconnect the first impedance matching unit **320** and the first electrode **410** to each other. The second coil **570** may be formed to surround a partial area of the RF load. A portion of the RF load on which the second coil **570** is disposed may correspond to the first sensor **330**.
[0121] Referring again to FIG. **7**, the description is made.
[0122] The controller **340** may be configured to control the power to be applied to the first electrode **410**. The controller **340** may be configured to control the power to be applied to the first electrode **410** based on the effective value of the voltage calculated through the first sensor **330**. The controller **340** may be configured to compensate for the loss of the power applied to the first electrode **410**. The controller **340** may be configured to control the plasma density in the chamber housing CH to be maintained at a constant level via the power loss compensation.
[0123] The controller **340** may be configured to control each of the power modules **310***a*, **310***b*, and **310***c* to adjust the power to be applied to the first electrode **410**. However, the present disclosure is not limited thereto, and the controller **340** may be configured to control several power modules (one or two of **310***a*, **310***b*, and **310***c*) to adjust the power to be applied to the first electrode **410**. The controller **340** may be configured to adjust the power to be applied to the first electrode **410** in real time. The controller **340** may be configured to control the plasma density in real time.
[0124] The control device that controls the overall substrate treating process of the substrate treating apparatus **200** has been described above. In accordance with the present disclosure, the control device may function as the controller **340**. However, the present disclosure is not limited thereto, and the controller **340** that is configured to only control the power adjustment function may be separately provided within the electromagnetic wave providing apparatus **300**. The controller

340 may be configured to be embodied as a computing device in the same form as that of the control device. The controller **340** may be configured to include the computing device and may be embodied as a user interface (U/I).
[0125] FIG. **10** is a first flowchart for illustrating an operation method of the controller constituting the electromagnetic wave providing apparatus according to the first embodiment of the present disclosure. Referring to FIG. **10**, the effective value V.sub.rms of the voltage is obtained through the first sensor **330** in S**611**, and the controller **340** may be configured to compare the effective value V.sub.rms with the reference value in S**612**. The reference value may be pre-stored in memory. In this case, the controller **340** may be configured to read the reference value from the memory and then compare the effective value V.sub.rms with the reference value. The reference value may be received from an external device. In this case, the controller **340** may be configured to receive the reference value from the external device and then compare the effective value V.sub.rms with the reference value. The reference value may be an ideal value V.sub.spec to be applied to the first electrode **410**.
[0126] When the effective value V.sub.rms is determined to be equal to the reference value V.sub.spec based on the comparison result between the effective value V.sub.rms and the reference value V.sub.spec, the controller **340** is configured not to adjust the power value output from the first power supply **310** in S**613**. That is, the output of the first power supply **310** does not change and is maintained at the same level.
[0127] On the contrary, when it is determined that the effective value V.sub.rms is not equal to the reference value V.sub.spec, the controller **340** is configured to adjust the power value output from the first power supply **310** in S**614**. That is, the output of the first power supply **310** changes.
[0128] The controller **340** may be configured to adjust the power value output from the first power supply **310** so that the effective value V.sub.rms matches the reference value V.sub.spec. The controller **340** may be configured to compensate for a difference between the effective value V.sub.rms and the reference value V.sub.spec. The controller **340** may be configured to adjust the power value output from the first power supply **310** based on the difference between the effective value V.sub.rms and the reference value V.sub.spec.
[0129] The controller **340** may be configured to control all power modules in the first power supply **310** so that the effective value V.sub.rms is equal to the reference value V.sub.spec. The controller **340** may be configured to control the first power module **310***a*, the second power module **310***b*, and the third power module **310***c*. The controller **340** may be configured to control the first power module **310***a*, the second power module **310***b*, and the third power module **310***c* so that the first power module **310***a*, the second power module **310***b*, and the third power module **310***c* output the power of the same value. However, the present disclosure is not limited thereto, and the controller **340** may be configured to control the first power module **310***a*, the second power module **310***b*, and the third power module **310***c* so as to output powers of different values. Alternatively, the controller **340** may be configured to control some power modules selected from the first power module **310***a*, the second power module **310***b*, and the third power module **310***c* to output the power of the same value and to control the other power modules selected from the first power module **310***a*, the second power module **310***b*, and the third power module **310***c* to output powers of different values.
[0130] The controller **340** may be configured to control the power module of a portion within the first power supply **310** so that the effective value V.sub.rms is equal to the reference value V.sub.spec. The controller **340** may be configured to control one power module selected from the first power module **310***a*, the second power module **310***b*, and the third power module **310***c*.
[0131] The remaining two power modules, except for one controlled power module, may maintain the same output value as before, that is, may not change the power value.
[0132] The controller **340** may be configured to control two power modules selected from the first power module **310***a*, the second power module **310***b*, and the third power module **310***c* so that the effective value V.sub.rms is equal to the reference value V.sub.spec. The controller **340** may be

configured to control the two power modules to output the power of the same value. Alternatively, the controller **340** may be configured to control the two power modules to output powers of different values. The remaining one power module, except for the two controlled power modules, may maintain the same output value as before, that is, may not change the power value.

[0133] The first sensor **330** and the controller **340** may be configured to perform their roles after the substrate treating process has started and then, a predetermined amount of time has elapsed. The first sensor **330** and the controller **340** may be configured to perform their roles after the first power supply **310** has started to provide the power to the first electrode **410**, and then, a predetermined amount of time has elapsed.

[0134] FIG. **11** is a second flowchart for illustrating an operation method of the controller constituting the electromagnetic wave providing apparatus according to the first embodiment of the present disclosure. When the effective value V.sub.rms has been obtained through the first sensor **330** in S**621**, the controller **340** is configured to calculate the difference between the effective value V.sub.rms and the reference value V.sub.spec in S**622**. Subsequently, the controller **340** is configured to determine whether the difference between the effective value V.sub.rms and the reference value V.sub.spec is a value within a predetermined range from the reference value V.sub.spec in S**623**. A factor for determining a valid range from the reference value V.sub.spec may be pre-stored in the memory. Alternatively, the factor may be transmitted from the external device. Alternatively, the factor may be determined as an arbitrary value by the controller **340**.

[0135] When the effective value V.sub.rms is determined to be within the valid range from the reference value V.sub.spec, the controller **340** is configured not to adjust the power value output from the first power supply **310** in S**624**. On the contrary, when the effective value V.sub.rms is determined to not be within the valid range from the reference value V.sub.spec, the controller **340** is configured to adjust the power value output from the first power supply **310** in S**625**. The controller **340** may be configured to adjust the power value output from the first power supply **310** so that the effective value V.sub.rms may be within the valid range from the reference value V.sub.spec.

[0136] The controller **340** may be configured to control all power modules in the first power supply **310** so that the effective value V.sub.rms becomes a value within the valid range from the reference value V.sub.spec. Alternatively, the controller **340** may be configured to control some of the power modules in the first power supply **310** so that the effective value V.sub.rms becomes a value within the valid range from the reference value V.sub.spec. The scheme in which the controller **340** controls the power modules in the first power supply **310** has been described above with reference to FIG. **10**, and thus, detailed description thereof is omitted herein.

[0137] The electromagnetic wave providing apparatus **300** as described above is an example of the electromagnetic wave providing apparatus configured to provide the power to the lower electrode in the substrate treating apparatus **200**. However, the present embodiment is not necessarily limited thereto. The electromagnetic wave providing apparatus **300** may provide the power to the upper electrode in the substrate treating apparatus **200**. This will be described below.

[0138] FIG. **12** is an example diagram for illustrating an electromagnetic wave providing apparatus according to a second embodiment of the present disclosure.

[0139] Referring to FIG. **12**, the electromagnetic wave providing apparatus **300** may be configured to include a second power supply **710**, a second impedance matching unit **720**, a second sensor **730**, and the controller **340**.

[0140] The electromagnetic wave providing apparatus **300** may provide the power to the second electrode **420** using an electromagnetic wave. Like the first electrode **410**, the second electrode **420** may generate the plasma in the inner space of the chamber housing CH using a process gas. The second electrode **420** may be placed in the inner space of the chamber housing CH. The second electrode **420** may be the upper electrode in the substrate treating apparatus **200**. For example, the second electrode **420** may be the showerhead unit **240** including the showerhead body **241**.

Alternatively, the second electrode **420** may be the antenna unit **280** including the antenna **282**.

[0141] The second power supply **710** may provide the power to the second electrode **420**. The power provided from the second power supply **710** may be transmitted to the second electrode **420** via the second impedance matching unit **720**. The second power supply **710** and the second impedance matching unit **720** may be interconnected to each other via a transmission line in a similar manner in which the first power supply **310** and the first impedance matching unit **320** are connected to each other.

[0142] The second power supply **710** may provide the power to the second electrode **420** using an RF signal. The second power supply **710** may provide the power to the second electrode **420** using a high-frequency signal. Referring to FIG. **4** to FIG. **6**, the second power supply **710** may be embodied as the second high-frequency power source **253** included in the substrate treating apparatus **200**.

[0143] The second power supply **710** may include a plurality of power modules. In the above descriptions, an example in which the first power supply **310** includes the first power module **310***a*, the second power module **310***b*, and the third power module **310***c* has been described. In the present embodiment, the second power supply **710** may be provided within the electromagnetic wave providing apparatus **300** in the same manner as the first power supply **310** may be provided.

[0144] The second impedance matching unit **720** may be disposed between the second power supply **710** and the second electrode **420**. The second impedance matching unit **720** may enable the RF signal provided from the second power supply **710** to be transmitted to the second electrode **420** without loss. The second impedance matching unit **720** may cancel the reactance term so that the RF signal is transmitted completely thereto. When the plurality of power modules apply frequency powers of different magnitudes, the second impedance matching unit **720** may play a role of matching the frequency powers applied from the plurality of power modules in the second power supply **710** with each other and provide the matching result to the second electrode **420**.

[0145] The second impedance matching unit **720** may be configured to include the first capacitor **510**, the second capacitor **520**, and the first coil **530**, in a similar manner to the first impedance matching unit **710**. The first capacitor **510**, the second capacitor **520**, and the first coil **530** have been described above with reference to FIG. **8**, and detailed descriptions thereof are omitted herein.

[0146] The second sensor **730** may be electrically connected to each of the second impedance matching unit **720** and the second electrode **420**. The second sensor **730** may measure the power value applied from each of the plurality of power modules in the second power supply **710** to the second electrode **420**. The second sensor **730** may calculate the effective value of the voltage applied from each of the plurality of power modules in the second power supply **710** to the second electrode **420**.

[0147] The second sensor **730** may be configured to include the rod **560** and the second coil **570** in a similar manner to the first sensor **330**. The rod **560** and the second coil **570** have been described above with reference to FIG. **9**, and detailed descriptions thereof are omitted herein.

[0148] The controller **340** may be configured to control the power to be applied to the second electrode **420**. The controller **340** may be configured to adjust the power to be applied to the second electrode **420** based on the effective value of the voltage calculated by the second sensor **730**. The controller **340** may be configured to control each of the power modules in the second power supply **710** to adjust the power to be applied to the second electrode **420**. Alternatively, the controller **340** may be configured to control some power modules in the second power supply **710** to adjust the power to be applied to the second electrode **420**.

[0149] The controller **340** may be configured to compare the effective value with the reference value and adjust the power value output from the second power supply **710** based on the result of the comparison. The controller **340** may be configured to adjust the power value output from the second power supply **710** based on whether the effective value matches the reference value. The controller **340** may be configured to apply the scheme described above with reference to FIG. **10** to adjust the power value output from all or some of the power modules in the second power supply **710**. The controller **340** may be configured to adjust the power value output from all or some of the power modules in the second power supply **710** depending on whether the effective value is within a predetermined range from the reference value. The controller **340** may be configured to apply the scheme as described above with reference to FIG. **11** to adjust the power value output from all or some of the power modules in the second power supply **710**.

[0150] The electromagnetic wave providing apparatus **300** may provide the power to either the lower electrode or the upper electrode in the substrate treating apparatus **200**. However, the present disclosure is not limited thereto. The electromagnetic wave providing apparatus **300** may provide the power to both the lower electrode and the upper electrode. The electromagnetic wave providing apparatus **300** may provide the power to the lower electrode and the upper electrode for the same time duration. However, the present disclosure is not limited thereto. The electromagnetic wave providing apparatus **300** may provide the power to both the lower electrode and the upper electrode for different time durations, respectively. Alternatively, the electromagnetic wave providing apparatus **300** may selectively provide the power to the lower electrode or the upper electrode depending on the plasma environment within the chamber housing CH.

[0151] FIG. **13** is an example diagram for illustrating an electromagnetic wave providing apparatus according to a third embodiment of the present disclosure.

[0152] Referring to FIG. **13**, the electromagnetic wave providing apparatus **300** may be configured to include the first power supply **310**, the first impedance matching unit **320**, the first sensor **330**, the second power supply **710**, the second impedance matching unit **720**, the second sensor **730**, and the controller **340**. Hereinafter, only differences from the contents as described above with reference to FIG. **7** to FIG. **12** will be described.

[0153] Each of the first power supply **310** and the second power supply **710** may include a plurality of power modules. The first power supply **310** and the second power supply **710** may include the same number of power modules. However, embodiments of the present disclosure are not limited thereto, and the first power supply **310** and the second power supply **710** may include different numbers of power modules. The number of power modules in the first power supply **310** may be determined based on influence of the first electrode **410** on maintaining of the plasma density. Similarly, the number of power modules in the second power supply **710** may be determined based on influence of the second electrode **420** on maintaining of the plasma density. The number of power modules in the first power supply **310** and the number of power modules the second power supply **710** may be equal to or different from each other depending on whether the influence of the first electrode **410** and the influence of the second electrode **420** are equal to or different from each other. The number of power modules in each of the first power supply **310** and the second power supply **710** may be determined so as to achieve real-time compensation.

[0154] The controller **340** may be configured to control the first power supply **310** and the second power supply **710** to output the power of the same value. The plurality of power modules in the first power supply **310** may output the power of the same value, or may output powers of different values. Alternatively, some power modules in the first power supply **310** may output the power of the same value, and the other power modules may output powers of different values. Similarly, the plurality of power modules in the second power supply **710** may output the power of the same value, or may output powers of different values. Alternatively, some power modules in the second power supply **710** may output the power of the same value, and the other power modules may output powers of different values.

[0155] The present disclosure as described above relates to a method of controlling the power to be provided to the electrode in the substrate treating apparatus **200**, based on the effective value V.sub.rms of the voltage. The substrate treating apparatus **200** that performs an etching process may have a lowered plasma density due to polymer accumulation resulting from the use of the substrate treating process, thereby causing reduced process yield. The plasma density may be represented based on the effective value of the voltage measured at the point to which the RF signal is applied. Thus, the power may be controlled based on this effective value, such that the plasma density may be stabilized. According to the present disclosure, the power may be controlled in real time based on the effective value of the voltage, thereby improving the mass productivity of the product.

[0156] Next, a method for controlling an impedance in the substrate treating apparatus **200** based on the effective value V.sub.rms of the voltage will be described. The V.sub.rms-based impedance control method may detect the change in the V.sub.rms in real time through a sensor. The Vrns-based impedance control method may maintain the V.sub.rms constant using a power change algorithm.

[0157] FIG. **14** is a flowchart for illustrating the impedance control method in the substrate treating apparatus of the electromagnetic wave providing apparatus according to the first embodiment of the present disclosure. The impedance control method may be performed from the start of the substrate treating process until the end thereof. Description will be made with reference to FIG. **14**.

[0158] Before starting a recipe for the impedance control, the controller **340** may be configured to define an item value for RF control in S**805**. For example, the item value for RF control may be a reference value V.sub.spec, a tolerance, etc. The tolerance means an error from the reference value that may be allowable.

[0159] The controller **340** may be configured to define the item value for RF control based on a type thereof. For example, the item value based on the type may include a reference value and its tolerance that may be applied when the RF power is provided to the first electrode **410**, a reference value and its tolerance that may be applied when the RF power is provided to the second electrode **420**, etc. The two reference values may vary depending on cases, such as a case in which a plasma environment is created using only the first electrode **410**, a case in which a plasma environment is created using only the second electrode **420**, or a case in which a plasma environment is created using both the first electrode **410** and the second electrode **420**.

[0160] Hereinafter, the case where the plasma environment is created using only the first electrode **410** will be described by way of example. However, an embodiment of the present disclosure is not limited thereto, and a following description may be applied in various cases including the case in which a plasma environment is created using only the second electrode **420**, or the case in which a plasma environment is created using both the first electrode **410** and the second electrode **420**.

[0161] When the substrate treating process starts, the first power supply **310** provides the RF power. For example, one power module among the first power module **310***a*, the second power module **310***b*, and the third power module **310***c* may provide the RF power.

[0162] Alternatively, two power modules selected among the first power module **310***a*, the second power module **310***b*, and the third power module **310***c* may provide the RF power.

[0163] Alternatively, the first power module **310***a*, the second power module **310***b*, and the third power module **310***c* may provide the RF power simultaneously.

[0164] When the first power supply **310** provides the RF power, a RF set power applied to the first electrode **410** may be greater than 0. The controller **340** may be configured to measure the effective value of the voltage through the first sensor **330** and determine whether the measured value is greater than 0 in S**810**. When the measured value is greater than 0, the controller **340** may be configured to output the item value related to the RF set power in S**815**. The item value related to the RF set power may be stored in the memory. The controller **340** may be configured to read the item value from the memory and then output the read item value. On the contrary, when the measured value is 0, the controller **340** may be configured to instruct the first power supply **310** to operate so that RF power may be provided. Alternatively, the controller **340** may be configured to determine that the first power supply **310** operates abnormally and notify a manager of this abnormal operation.

[0165] A predetermined time duration is required for the RF to be applied to the first electrode **410** to be stabilized. When the RF power has been applied to the first electrode **410**, the controller **340**

is configured not to immediately start the recipe for impedance control, but to wait for the predetermined time duration in S**820**. The predetermined time duration may be predetermined. The predetermined time duration may be determined based on the type of the substrate treating process.
[0166] After the predetermined time duration has elapsed, the first sensor **330** may measure the V.sub.rms value corresponding to the effective value based on the RF power applied to the first electrode **410** from the first power supply **310** in S**825**. The controller **340** may be configured to calculate a difference between the V.sub.spec value and the V.sub.rms value, and determine whether the difference is within the tolerance in S**830**. The tolerance may be determined to be within a range in which a problem does not occur in the substrate treating process.
[0167] When the difference between the V.sub.spec value and the V.sub.rms value is within the tolerance, the controller **340** maintains the RF power at a non-changed level. The controller **340** is configured not to compensate for the RF power.
[0168] On the contrary, when the difference between the V.sub.spec value and the V.sub.rms value is outside the tolerance, the controller **340** is configured to control the first power supply **310** to compensate for the RF power in S**835**. The controller **340** may be configured to control all power modules in the first power supply **310** so that the V.sub.rms value does not exceed the tolerance from the V.sub.spec value. Alternatively, the controller **340** may be configured to control some of the power modules in the first power supply **310** so that the V.sub.rms value does not exceed the tolerance from the V.sub.spec value. The controller **340** may be configured to calculate a compensation value using a following Equation:

RF set power compensation value=*A**(*V*.sub.spec.sup.2-*V*.sub.rms.sup.2)
[0169] where A means a reciprocal of the impedance. When the RF power is provided to the first electrode **410**, the impedance may be measured in a section of the line connecting the first power supply **310** and the first electrode **410** to each other.
[0170] A process of measuring the V.sub.rms value, determining whether the difference between the V.sub.spec value and the V.sub.rms value is within the tolerance, and compensating the RF power based on the determination result in S**825** to S**835** may be repeated at a regular time interval. The above process in S**825** to S**835** may be continuously performed until the substrate treating process is terminated in S**840**.
[0171] Although embodiments of the present disclosure have been described with reference to the accompanying drawings, the present disclosure is not limited to the above embodiments, but may be implemented in various different forms. A person skilled in the art may appreciate that the present disclosure may be practiced in other concrete forms without changing the technical concepts or characteristics of the present disclosure. Therefore, it should be appreciated that the embodiments as described above is not restrictive but illustrative in all respects.

Claims

1. A substrate treating apparatus comprising: a chamber housing having an inner space defined therein for treating a substrate therein; a process gas supply unit for providing process gas into the inner space of the chamber housing; a first electrode disposed in the inner space of the chamber housing; and an electromagnetic wave providing apparatus configured to provide power to the first electrode using an electromagnetic wave, wherein the electromagnetic wave providing apparatus configured to control a plasma density generated in the inner space of the chamber housing, based on an effective value of a voltage related to the power.
2. The substrate treating apparatus of claim 1, wherein the electromagnetic wave providing apparatus includes: a first power supply for outputting the power to the first electrode; a first sensor installed on a line connecting the first power supply and the first electrode to each other; and a controller configured to compensate for loss of the power based on the effective value obtained

through the first sensor.
3. The substrate treating apparatus of claim 1, wherein the electromagnetic wave providing apparatus is configured to adjust the power based on a difference value between the effective value and a reference value.
4. The substrate treating apparatus of claim 3, wherein the electromagnetic wave providing apparatus is configured to adjust the power based on a result of comparison between the difference value and a tolerance.
5. The substrate treating apparatus of claim 1, wherein the electromagnetic wave providing apparatus is configured to adjust the power based on whether the effective value and a reference value are equal to each other.
6. The substrate treating apparatus of claim 2, wherein the controller is configured to compensate for loss of power after a predetermined time duration has elapsed from a time when a substrate treating process starts.
7. The substrate treating apparatus of claim 2, wherein the controller is configured to calculate a compensation value for compensating for the loss of power, based on the effective value, the reference value, and an impedance in a path connecting the first power supply and the first electrode to each other.
8. The substrate treating apparatus of claim 7, wherein the controller is configured to calculate a difference value between a square of the reference value and a square of the effective value, and calculate the compensation value based on the difference value and the impedance.
9. The substrate treating apparatus of claim 8, wherein the controller is configured to calculate the compensation value by multiplying the difference value by a reciprocal of the impedance.
10. The substrate treating apparatus of claim 2, wherein the first sensor includes: a load connected to the first power supply via a second transmission line and connected to the first electrode via a third transmission line; and a second coil winding the load.
11. The substrate treating apparatus of claim 2, wherein the electromagnetic wave providing apparatus further includes a first impedance matching unit installed on a line connecting the first power supply and the first sensor to each other.
12. The substrate treating apparatus of claim 11, wherein the first impedance matching unit includes: a fourth transmission line connecting the first power supply and the first sensor to each other; a first capacitor installed on the fourth transmission line; a first coil installed on the fourth transmission line; a fifth transmission line branched from the fourth transmission line and connected to a ground; and a second capacitor installed on the fifth transmission line.
13. The substrate treating apparatus of claim 12, wherein the first capacitor is disposed closer to the first sensor than the first coil is.
14. The substrate treating apparatus of claim 12, wherein a point at which the fifth transmission line is branched from the fourth transmission line is disposed closer to the first power supply than the first coil is.
15. The substrate treating apparatus of claim 1, wherein the first electrode is embodied as an electrostatic chuck disposed in the inner space of the chamber housing so as to support the substrate thereon.
16. The substrate treating apparatus of claim 1, further comprising a second electrode disposed in the inner space of the chamber housing or disposed adjacent to an outer surface of the chamber housing, wherein the electromagnetic wave providing apparatus is configured to provide the power to the first electrode and the second electrode.
17. The substrate treating apparatus of claim 16, wherein the second electrode is embodied as a showerhead unit for feeding the process gas into the inner space of the chamber housing, or as an antenna unit for generating an electromagnetic field in the inner space of the chamber housing.
18. An electromagnetic wave providing apparatus included in a process chamber configured to treat a substrate using plasma, wherein the electromagnetic wave providing apparatus comprises: a

power supply configured to provide power to an electrode received in the process chamber using an electromagnetic wave; an impedance matching unit configured to perform impedance matching between the power supply and the electrode; a sensor installed on a line connecting the power supply and the electrode to each other; and a controller configured to compensate for loss of the power based on an effective value of a voltage obtained through the sensor, wherein the controller is configured to control a plasma density generated in an inner space of the process chamber based on the effective value.

19. The electromagnetic wave providing apparatus of claim 18, wherein the controller is configured to calculate a compensation value for compensating for the loss of power based on an impedance in a path connecting the power supply and the electrode to each other, the effective value, and a reference value, wherein the controller is configured to calculate a difference value between a square of the reference value and a square of the effective value, and to multiply the difference value by a reciprocal of the impedance to obtain the compensation value.

20. A substrate treating apparatus comprising: a chamber housing having an inner space defined therein for treating a substrate therein; a process gas supply unit for providing process gas into the inner space of the chamber housing; a first electrode disposed in a lower area of the inner space of the chamber housing; a second electrode disposed in an upper area of the inner space of the chamber housing; and an electromagnetic wave providing apparatus configured to provide power to at least one of the first electrode and the second electrode using an electromagnetic wave, wherein the electromagnetic wave providing apparatus includes: a first power supply for outputting the power to the first electrode; a first sensor installed on a line connecting the first power supply and the first electrode to each other; a second power supply for outputting the power to the second electrode; a second sensor installed on a line connecting the second power supply and the second electrode to each other; and a controller configured to compensate for loss of the power, based on an effective value of a voltage obtained through at least one of the first sensor and the second sensor.