Description

Title of Invention: PLASMA PROCESSING APPARATUS AND SUBSTRATE PROCESSING APPARATUS

Technical Field

[0001]

Exemplary embodiments of the present disclosure relate to a plasma processing apparatus and a substrate processing apparatus.

Background Art

[0002]

A technique for providing a plasma viewport for a high-temperature environment in a semiconductor processing apparatus is described in Patent Literature 1.

Citation List

Patent Literature

[0003]

Patent Literature 1: PCT Japanese Translation Patent Publication No. 2022-545274

Summary of Invention

Technical Problem

[0004]

The present disclosure provides a technique that can recover a substance flowing out of a substrate processing space.

Solution to Problem

[0005]

A plasma processing apparatus in one exemplary embodiment of the present

disclosure includes a chamber having a plasma processing space; and a plasma viewport attached to the chamber, in which the plasma viewport includes: a first window; a second window placed between the first window and the plasma processing space; a third window placed between the first window and the second window; and a lattice structure body placed between the second window and the third window.

Advantageous Effect of Invention

[0006]

According to one exemplary embodiment of the present disclosure, it is possible to provide a technique that can recover particles discharged from a substrate processing space.

Brief Description of Drawings

[0007]

[Figure 1] Figure 1 is a diagram illustrating a configuration example of a plasma processing system.

[Figure 2] Figure 2 is a diagram illustrating a configuration example of a plasma processing apparatus.

[Figure 3] Figure 3 is a diagram illustrating a configuration example of a plasma viewport.

[Figure 4] Figure 4 is a diagram illustrating a configuration example of a plasma viewport frame.

[Figure 5] Figure 5 is a diagram illustrating a configuration example of the plasma viewport when a first window is viewed from a second window side.

[Figure 6] Figure 6 is a diagram illustrating an example of an Octapeak lattice structure body.

[Figure 7] Figure 7 is a diagram illustrating an example of a BiTriangle lattice structure body.

[Figure 8] Figure 8 is a diagram illustrating an example of a Dodecahedron lattice structure body.

[Figure 9] Figure 9 is a diagram illustrating an example of a QuadDiametral lattice structure body.

[Figure 10] Figure 10 is a diagram illustrating an example of a Star lattice structure body.

[Figure 11] Figure 11 is a diagram illustrating an example of a TriDiametral lattice structure body.

[Figure 12] Figure 12 is a diagram illustrating another configuration example of the plasma viewport.

[Figure 13] Figure 13 is a diagram illustrating another configuration example of the plasma viewport when the first window is viewed from the second window side.

[Figure 14] Figure 14 is a diagram illustrating another configuration example of a plasma processing apparatus.

Description of Embodiments

[0008]

Hereinafter each embodiment of the present disclosure will be described.

[0009]

In one exemplary embodiment, there is provided a plasma processing apparatus including: a chamber having a plasma processing space; and a plasma viewport attached to the chamber, in which the plasma viewport includes: a first window; a second window placed between the first window and the plasma processing space; a third window placed between the first window and the second

window; and a lattice structure body placed between the second window and the third window.

[0010]

In one exemplary embodiment, the first window includes a quartz material.

[0011]

In one exemplary embodiment, the third window includes a sapphire material.

[0012]

In one exemplary embodiment, the second window has multiple through-holes communicating with the plasma processing space.

[0013]

In one exemplary embodiment, the lattice structure body includes a ceramic material or an anodized aluminum material.

[0014]

In one exemplary embodiment, the lattice structure body has a porosity of 1% to 90%.

[0015]

In one exemplary embodiment, the lattice structure body has at least one lattice structure selected from the group consisting of Octapeak, BiTriangle, Dodecahedron, QuadDiametral, Star, and TriDiametral.

[0016]

In one exemplary embodiment, the lattice structure body is placed to overlap with the first window when the first window is viewed from the second window.

[0017]

In one exemplary embodiment, the lattice structure body is placed to surround a space overlapping with the first window when the first window is viewed from the

second window.

[0018]

In one exemplary embodiment, there is provided a substrate processing apparatus including: a chamber having a substrate processing space; and a viewport attached to the chamber, in which the viewport includes: a frame defining a first space communicating with the substrate processing space; a first window; and a lattice structure body placed between the first window and the substrate processing space in the first space.

[0019]

In one exemplary embodiment, the first window includes a material selected from the group consisting of quartz, sapphire, YAG, and Y_2O_3.

[0020]

In one exemplary embodiment, the lattice structure body includes a ceramic material or an anodized aluminum material.

[0021]

In one exemplary embodiment, the lattice structure body has a porosity of 1% to 90%.

[0022]

In one exemplary embodiment, the lattice structure body has at least one lattice structure selected from the group consisting of Octapeak, BiTriangle, Dodecahedron, QuadDiametral, Star, and TriDiametral.

[0023]

In one exemplary embodiment, there is provided a substrate processing apparatus including: a chamber having a substrate processing space; a member having a first space communicating with the substrate processing space; and a

lattice structure body placed in the first space.

[0024]

In one exemplary embodiment, the substrate processing apparatus further includes: an exhaust system communicating with the substrate processing space via the first space.

[0025]

In one exemplary embodiment, the lattice structure body includes a ceramic material or an anodized aluminum material.

[0026]

In one exemplary embodiment, the lattice structure body has a porosity of 1% to 90%.

[0027]

In one exemplary embodiment, the lattice structure body has at least one lattice structure selected from the group consisting of Octapeak, BiTriangle, Dodecahedron, QuadDiametral, Star, and TriDiametral.

[0028]

Each embodiment of the present disclosure will be described in detail below with reference to the drawings. Furthermore, identical or similar elements in each drawing are denoted by the same reference numeral, and redundant explanations are omitted. Unless otherwise specified, positional relationships of up, down, left, right, and the like will be explained based on positional relationships illustrated in the drawings. The dimensional ratios illustrated in the drawings do not represent actual ratios, and actual ratios are not limited to those illustrated.

[0029] <Example of Plasma Processing System>

Figure 1 is a diagram illustrating a configuration example of a plasma

processing system. In one embodiment, the plasma processing system includes a plasma processing apparatus 1 and a controller 2. The plasma processing system is one example of a substrate processing system and the plasma processing apparatus 1 is one example of a substrate processing apparatus. The plasma processing apparatus 1 includes a plasma processing chamber 10, a substrate support 11 and a plasma generator 12. The plasma processing chamber 10 has a plasma processing space. Further, the plasma processing chamber 10 has at least one gas supply port for supplying at least one processing gas into the plasma processing space, and at least one gas exhaust port for exhausting the gas from the plasma processing space. The gas supply port is connected to the gas supply 20, which will be described below, and the gas exhaust port is connected to the exhaust system 40, which will be described below. The substrate support 11 is placed in the plasma processing space and has a substrate support surface for supporting a substrate.

[0030]

The plasma generator 12 is configured to generate plasma from at least one processing gas supplied into the plasma processing space. Plasma generated in the plasma processing space may be Capacitively Coupled Plasma (CCP), Inductively Coupled Plasma (ICP), Electron-Cyclotron-resonance (ECR) plasma, Helicon Wave Plasma (HWP), Surface Wave Plasma (SWP), or the like. Furthermore, various types of plasma generators, including an Alternating Current (AC) plasma generator and a Direct Current (DC) plasma generator, may be used. In one embodiment, an AC signal (AC power) used in the AC plasma generator has a frequency in the range of 100 kHz to 10 GHz. Accordingly, the AC signal includes a Radio Frequency (RF) signal and a microwave signal. In one embodiment, the

RF signal has a frequency in the range of 100 kHz to 150 MHz.

[0031]

The controller 2 processes computer-executable instructions that cause the plasma processing apparatus 1 to execute various steps described in the present disclosure. The controller 2 may be configured to control each element of the plasma processing apparatus 1 to execute the various steps described herein. In one embodiment, a part or all of the controller 2 may be included in the plasma processing apparatus 1. The controller 2 may include a processor 2a1, a storage 2a2, and a communication interface 2a3. The controller 2 is implemented, for example, by a computer 2a. The processor 2a1 may be configured to read a program from the storage 2a2 and perform various control operations by executing the read program. This program may be stored in the storage 2a2 in advance, or may be acquired via a medium when needed. The acquired program is stored in the storage 2a2 and read from the storage 2a2 and executed by the processor 2a1. The medium may be various storage media readable by the computer 2a, or may be a communication line connected to the communication interface 2a3. The processor 2a1 may be a Central Processing Unit (CPU). The storage 2a2 may include Random Access Memory (RAM), Read Only Memory (ROM), Hard Disk Drive (HDD), Solid State Drive (SSD), or a combination thereof. The communication interface 2a3 may communicate with the plasma processing apparatus 1 via a communication line such as a Local Area Network (LAN).

[0032]

Hereinafter, a configuration example of a capacitively coupled plasma processing apparatus as an example of the plasma processing apparatus 1 will be described. Figure 2 is a diagram illustrating a configuration example of the

capacitively coupled plasma processing apparatus.

[0033]

The capacitively coupled plasma processing apparatus 1 includes the plasma processing chamber 10 (also simply called the "chamber"), the gas supply 20, a power source 30, and the exhaust system 40. Further, the plasma processing apparatus 1 includes a substrate support 11 and a gas introduction unit. The gas introduction unit is configured to introduce at least one processing gas into the plasma processing chamber 10. The gas introduction unit includes a shower head 13. The substrate support 11 is placed in the plasma processing chamber 10. The shower head 13 is placed above the substrate support 11. In one embodiment, the shower head 13 constitutes at least a part of a ceiling of the plasma processing chamber 10. The plasma processing chamber 10 has a plasma processing space 10s defined by the shower head 13, a sidewall 10a of the plasma processing chamber 10, and the substrate support 11. The plasma processing chamber 10 is grounded. The shower head 13 and the substrate support 11 are electrically insulated from a housing of the plasma processing chamber 10.

[0034]

The substrate support 11 includes a main body 111 and a ring assembly 112. The main body 111 has a central region 111a for supporting a substrate W and an annular region 111b for supporting the ring assembly 112. The wafer is one example of the substrate W. The annular region 111b of the main body 111 surrounds the central region 111a of the main body 111 in a plan view. The substrate W is placed on the central region 111a of the main body 111 and the ring assembly 112 is placed on the annular region 111b of the main body 111 to surround the substrate W on the central region 111a of the main body 111. Accordingly, the

central region 111a is also referred to as a substrate support surface for supporting the substrate W, and the annular region 111b is also referred to as a ring support surface for supporting the ring assembly 112.

[0035]

In one embodiment, the main body 111 includes a base 1110 and an electrostatic chuck 1111. The base 1110 includes a conductive member. The conductive member of the base 1110 may function as a lower electrode. The electrostatic chuck 1111 is placed on the base 1110. The electrostatic chuck 1111 includes a ceramic member 1111a and an electrostatic electrode 1111b placed in the ceramic member 1111a. The ceramic member 1111a has a central region 111a. In one embodiment, the ceramic member 1111a also has an annular region 111b. Other members that surround the electrostatic chuck 1111, such as an annular electrostatic chuck and an annular insulating member, may have the annular region 111b. In this case, the ring assembly 112 may be placed on the annular electrostatic chuck or the annular insulating member, or may be placed on both the electrostatic chuck 1111 and the annular insulating member. Further, at least one RF/DC electrode coupled to an RF power source 31 and/or a DC power source 32 described below may be placed in the ceramic member 1111a. In this case, at least one RF/DC electrode functions as the lower electrode. When the bias RF signal and/or the DC signal described below are supplied to at least one RF/DC electrode, the RF/DC electrode is also called a bias electrode. The conductive member of the base 1110 and at least one RF/DC electrode may function as multiple lower electrodes. Further, the electrostatic electrode 1111b may function as the lower electrode. Accordingly, the substrate support 11 includes at least one lower electrode.

[0036]

The ring assembly 112 includes one or more annular members. In one embodiment, one or more annular members include one or more edge rings and at least one cover ring. The edge ring is formed of a conductive material or an insulating material, and the cover ring is formed of an insulating material.

[0037]

Further, the substrate support 11 may include a temperature-controlled module configured to adjust at least one of the electrostatic chuck 1111, the ring assembly 112, and the substrate to a target temperature. The temperature-controlled module may include a heater, a heat transfer medium, a flow path 1110a, or a combination thereof. A heat transfer fluid, such as brine or gas, flows through the flow path 1110a. In one embodiment, the flow path 1110a is formed in the base 1110, and one or more heaters are placed in the ceramic member 1111a of the electrostatic chuck 1111. Further, the substrate support 11 may include a heat transfer gas supply configured to supply a heat transfer gas to a gap between a rear surface of the substrate W and the central region 111a.

[0038]

The shower head 13 is configured to introduce at least one processing gas from the gas supply 20 into the plasma processing space 10s. The shower head 13 has at least one gas supply port 13a, at least one gas diffusion chamber 13b, and multiple gas introduction ports 13c. The processing gas supplied to the gas supply port 13a passes through the gas diffusion chamber 13b and is introduced into the plasma processing space 10s from the multiple gas introduction ports 13c. Further, the shower head 13 includes at least one upper electrode. The gas introduction unit may include, in addition to the shower head 13, one or more side gas injectors

(SGI) that are attached to one or more openings formed in the sidewall 10a.

[0039]

The gas supply 20 may include at least one gas source 21 and at least one flow rate controller 22. In one embodiment, the gas supply 20 is configured to supply at least one processing gas from the respective corresponding gas sources 21 to the shower head 13 via the respective corresponding flow rate controllers 22. Each flow rate controller 22 may include, for example, a mass flow controller or a pressure-controlled flow rate controller. Further, the gas supply 20 may include at least one flow rate modulation device that modulates or pulses the flow rate of at least one processing gas.

[0040]

The power source 30 includes the RF power source 31 coupled to the plasma processing chamber 10 via at least one impedance matching circuit. The RF power source 31 is configured to supply at least one RF signal (RF power) to at least one lower electrode and/or at least one upper electrode. As a result, plasma is generated from at least one processing gas supplied into the plasma processing space 10s. Accordingly, the RF power source 31 may function as at least a part of the plasma generator 12. Further, by supplying the bias RF signal to at least one lower electrode, a bias potential is generated in the substrate W, and ion components in the generated plasma can be drawn into the substrate W.

[0041]

In one embodiment, the RF power source 31 includes a first RF generator 31a and a second RF generator 31b. The first RF generator 31a is configured to be coupled to at least one lower electrode and/or at least one upper electrode via at least one impedance matching circuit to generate a source RF signal (source RF

power) for generating plasma. In one embodiment, the source RF signal has a frequency in the range of 10 MHz to 150 MHz. In one embodiment, the first RF generator 31a may be configured to generate multiple source RF signals having different frequencies. The generated one or more source RF signals are supplied to at least one lower electrode and/or at least one upper electrode.

[0042]

The second RF generator 31b is configured to be coupled to at least one lower electrode via at least one impedance matching circuit to generate the bias RF signal (bias RF power). A frequency of the bias RF signal may be the same as or different from a frequency of the source RF signal. In one embodiment, the bias RF signal has a frequency lower than the frequency of the source RF signal. In one embodiment, the bias RF signal has a frequency in the range of 100 kHz to 60 MHz. In one embodiment, the second RF generator 31b may be configured to generate multiple bias RF signals having different frequencies. The generated one or more bias RF signals are supplied to at least one lower electrode. Further, in various embodiments, at least one of the source RF signal and the bias RF signal may be pulsed.

[0043]

Further, the power source 30 may include the DC power source 32 coupled to the plasma processing chamber 10. The DC power source 32 includes a first DC generator 32a and a second DC generator 32b. In one embodiment, the first DC generator 32a is configured to be connected to at least one lower electrode to generate a first DC signal. The generated first DC signal is applied to at least one lower electrode. In one embodiment, the second DC generator 32b is configured to be connected to at least one upper electrode to generate a second DC signal. The

generated second DC signal is applied to at least one upper electrode.

[0044]

In various embodiments, the first and second DC signals may be pulsed. In this case, the sequence of voltage pulses is applied to at least one lower electrode and/or at least one upper electrode. The voltage pulse may have a pulse waveform of a rectangle, a trapezoid, a triangle or a combination thereof. In one embodiment, a waveform generator for generating the sequence of voltage pulses from the DC signal is connected between the first DC generator 32a and at least one lower electrode. Therefore, the first DC generator 32a and the waveform generator constitute a voltage pulse generator. When the second DC generator 32b and the waveform generator constitute the voltage pulse generator, the voltage pulse generator is connected to at least one upper electrode. The voltage pulse may have a positive polarity or a negative polarity. Further, the sequence of the voltage pulses may include one or more positive voltage pulses and one or more negative voltage pulses in one cycle. The first and second DC generators 32a and 32b may be provided in addition to the RF power source 31, and the first DC generator 32a may be provided instead of the second RF generator 31b.

[0045]

The exhaust system 40 may be connected to, for example, a gas exhaust port 10e placed at a bottom portion of the plasma processing chamber 10. The exhaust system 40 may include a pressure adjusting valve and a vacuum pump. The pressure in the plasma processing space 10s is adjusted by the pressure adjusting valve. The vacuum pump may include a turbo molecular pump, a dry pump, or a combination thereof.

[0046]

In one embodiment, the plasma processing apparatus 1 further includes a plasma viewport 200 and a detector 201.

[0047]

In one embodiment, the plasma viewport 200 is attached to the sidewall 10a of the chamber 10.

[0048]

Figure 3 is a diagram illustrating a configuration example of the plasma viewport 200. In one embodiment, the plasma viewport 200 includes a first window 250, a second window 251, a third window 252, a frame 253, and a lattice structure body 254.

[0049]

The second window 251, the lattice structure body 254, the third window 252, and the first window 250 are placed in this order from the plasma processing space 10s in the chamber 10 toward the detector 201 outside the chamber 10.

[0050]

The second window 251 has multiple through-holes 300 communicating with the plasma processing space 10s. Each through-hole 300 may have a diameter of 0.1 mm to 10 mm. In this example, the sidewall 10a of the chamber 10 has an inner sidewall 310 and an outer sidewall 311. The inner sidewall 310 is a deposition shield that suppresses adhering of a reaction product generated during plasma processing to the outer sidewall 311. The inner sidewall 310 may be removable from the chamber 10. In one embodiment, the second window 251 is attached to the inner sidewall 310. The second window 251 may be detachably attached to the inner sidewall 310. The second window 251 is placed to face the plasma processing space 10s between the substrate support 11 and the shower

head 13.

[0051]

In one embodiment, the frame 253 holds the lattice structure body 254, the third window 252, and the first window 250. The frame 253 is attached to the outer sidewall 311 of the chamber 10. The frame 253 may be detachably attached to the outer sidewall 311.

[0052]

In one embodiment, the frame 253 has a cylindrical portion 350 placed on a plasma processing space 10s side and a flange portion 351 placed on a detector 201 side.

[0053]

In one embodiment, the cylindrical portion 350 has a first portion 370 configured to define a first space 360 communicating with the plasma processing space 10s, a window holder 371 configured to hold the third window 252, and a second portion 372 configured to define a second space 361 between the third window 252 and the first window 250. The first space 360 defined by the first portion 370 communicates with the plasma processing space 10s via the through-hole 300 of the second window 251. The window holder 371 is configured to hold the third window 252 between the first space 360 and the second space 361. The window holder 371 may be configured to removably hold the third window 252.

[0054]

In one embodiment, the flange portion 351 is configured to hold the first window 250. The flange portion 351 may have a fixing mechanism for fixing the frame 253 to the outer sidewall 311 of the chamber 10. The flange portion 351 may be configured to removably hold the first window 250.

[0055]

As illustrated in Figure 4, the cylindrical portion 350 may have a sidewall 350a forming a substantially rectangular opening OP1. The flange portion 351 may have a substantially rectangular plate shape.

[0056]

The third window 252 includes a material selected from the group consisting of quartz, sapphire, YAG, and Y_2O_3. In one embodiment, the third window 252 includes a sapphire material. The third window 252 may include the sapphire material as a main component and may be formed of sapphire. The third window 252 has a light transparency. The third window 252 may have a rectangular or circular plate shape.

[0057]

The first window 250 includes a material selected from the group consisting of quartz, sapphire, YAG, and Y_2O_3. In one embodiment, the first window 250 includes a quartz material. The first window 250 may include the quartz material as a main component, and may be formed of quartz. The first window 250 has the light transparency. The first window 250 may have a rectangular or circular plate shape. The first window 250 may have a diameter larger than that of the third window 252. The second window 251, the third window 252, and the first window 250 are placed so that window surfaces thereof are parallel to each other and are placed in a nearly straight-line shape.

[0058]

The lattice structure body 254 is placed in the first space 360 between the second window 251 and the third window 252 in the frame 253. As illustrated in Figure 5, the lattice structure body 254 is placed so as to overlap with the first

window 250 when the first window 250 is viewed from the second window 251 (plasma processing space 10s) (when the lattice structure 254 is projected onto the first window 250 in a horizontal direction viewed from a side). In one embodiment, in the example as illustrated in Figures 3 to 5, the lattice structure body 254 is placed throughout the entire first space 360. The lattice structure body 254 is placed to cover an entire surface of the opening OP1. The lattice structure body 254 includes a ceramic material or an anodized aluminum material. The lattice structure body 254 has a porosity of 1% to 90%.

[0059]

The lattice structure body 254 may have at least one lattice structure selected from the group consisting of Octapeak, BiTriangle, Dodecahedron, QuadDiametral, Star, and TriDiametral. The lattice structure is a structure that creates a three-dimensional object by arranging multiple unit cells periodically.

[0060]

Figure 6 is a diagram illustrating an example of an Octapeak lattice structure body 254-1. As illustrated in Figure 6(a), the Octapeak lattice structure body 254-1 has a unit cell 254a in which eight beams curved in an arc shape are coupled to each other to form a peak at a center of each face of a regular hexahedron. As illustrated in Figure 6(b), the lattice structure body 254-1 has a three-dimensional shape in which multiple unit cells 254a are arranged regularly in a vertical direction, in a horizontal direction, and in a depth direction and connected to each other.

[0061]

Figure 7 is a diagram illustrating an example of a BiTriangle lattice structure body 254-2. As illustrated in Figure 7(a), the BiTriangle lattice structure body 254-2 has a unit cell 254b formed by coupling two triangular beams to each other. As

illustrated in Figure 7(b), the lattice structure body 254-2 has a three-dimensional shape in which multiple unit cells 254b are arranged regularly in the vertical direction, in the horizontal direction, and in the depth direction and connected to each other.

[0062]

Figure 8 is a diagram illustrating an example of a Dodecahedron lattice structure body 254-3. As illustrated in Figure 8(a), the Dodecahedron lattice structure body 254-3 has a unit cell 254c of which a basic structure is a dodecagonal beam. As illustrated in Figure 8(b), the lattice structure body 254-3 has a three-dimensional shape in which multiple unit cells 254c are arranged regularly in the vertical direction, in the horizontal direction, and in the depth direction and connected to each other.

[0063]

Figure 9 is a diagram illustrating an example of a QuadDiametral lattice structure body 254-4. As illustrated in Figure 9(a), the QuadDiametral lattice structure body 254-4 has a unit cell 254d in which four straight beams are each coupled at a center thereof. As illustrated in Figure 9(b), the lattice structure body 254-4 has a three-dimensional shape in which multiple unit cells 254d are arranged regularly in the vertical direction, in the horizontal direction, and in the depth direction and connected to each other.

[0064]

Figure 10 is a diagram illustrating an example of a Star lattice structure body 254-5. As illustrated in Figure 10(a), the Star lattice structure body 254-5 has a unit cell 254e in which multiple beams having sharp angles that protrude outward are coupled to each other. As illustrated in Figure 10(b), the lattice structure body 254-

5 has a three-dimensional shape in which multiple unit cells 254e are arranged regularly in the vertical direction, in the horizontal direction, and in the depth direction and connected to each other.

[0065]

Figure 11 is a diagram illustrating an example of a TriDiametral lattice structure body 254-6. As illustrated in Figure 11(a), the TriDiametral lattice structure body 254-6 has a unit cell 254f in which three straight beams are each coupled at a center thereof. As illustrated in Figure 11(b), the lattice structure body 254-6 has a three-dimensional shape in which multiple unit cells 254f are arranged regularly in the vertical direction, in the horizontal direction, and in the depth direction and connected to each other.

[0066]

The lattice structure body 254 is not limited to the examples illustrated in Figures 6 to 11, and may have other lattice structures. The lattice structure body 254 may be placed so as to completely overlap with the first window 250 when the first window 250 is viewed from the second window 251, or may be placed so as to partially overlap with the first window 250.

[0067]

In the example illustrated in Figure 2, the detector 201 is placed outside the outer sidewall 311. The detector 201 may be placed near the first window 250. The detector 201 may be configured to optically measure a state of the plasma processing space 10s via the plasma viewport 200. The detector 201 may be at least one selected from the group consisting of a camera, an optical emission spectrometer (OES), and a spectrometer. The detector 201 may or may not be included as a part of the plasma processing apparatus 1. The detector 201 may be

installed only when in use, or may be permanently installed. The detector 201 may be configured to measure a wear status and a contamination status of the chamber 10 or a component thereof. The detector 201 may be used to detect other objects.

[0068] <Example of Plasma Processing>

Plasma processing is performed in the plasma processing apparatus 1 which is described above. The plasma processing includes etching processing for etching a film on a substrate W using plasma. In one embodiment, the plasma processing is executed by a controller 2 in the plasma processing apparatus 1.

[0069]

In the plasma processing apparatus 1 illustrated in Figure 2, first, the substrate W is transported into the chamber 10 by a transport arm, placed on the substrate support 11 by a lifter, and held by suction on the substrate support 11.

[0070]

Next, the processing gas is supplied to the plasma processing space 10s through the shower head 13 by the gas supply 20. The processing gas supplied at this time includes a gas that generates active species necessary for the etching processing of the substrate W.

[0071]

A source RF signal for generating plasma is supplied to the upper electrode and/or the lower electrode by the RF power source 31 of the plasma generator 12. A bias signal for drawing the ion component in plasma into the substrate is supplied to the lower electrode by the RF power source 31 or the DC power source 32. The environment in the plasma processing space 10s is exhausted from the gas exhaust port 10e, and the inside of the plasma processing space 10s is depressurized. In this way, plasma is generated from the processing gas on the substrate support 11

of the plasma processing space 10s, and the substrate W is etched.

[0072]

During the plasma processing, the state of the plasma processing space 10s may be optically detected by the detector 201. Light in the plasma processing space 10s passes through the second window 251, the lattice structure body 254, the third window 252, and the first window 250 of the plasma viewport 200 in this order and is detected by the detector 201. During the plasma processing, a deposit component and an etching component are generated in the plasma processing space 10s due to the processing gas or plasma. A part of these components may enter the frame 253 through the through-hole 300 of the second window 251. In one embodiment, the component that enters the frame 253 is consumed by being deposited on the lattice structure 254 that has a large surface area, or by scraping (wearing down) the lattice structure body 254. In this way, reaching of the deposit component and the etching component in the plasma processing space 10s to the third window 252 or the first window 250 is suppressed.

[0073]

According to the present exemplary embodiment, the plasma processing apparatus 1 includes the chamber 10 having the plasma processing space 10s and the plasma viewport 200 attached to the chamber 10, in which the plasma viewport 200 includes a first window 250, the second window 251 placed between the first window 250 and the plasma processing space 10s, the third window 252 placed between the first window 250 and the second window 251, and the lattice structure body 254 placed between the second window 251 and the third window 252. As a result, the deposit component or the etching component that flows out from the plasma processing space 10s can be consumed in the lattice structure body 254,

and thereby a substance that flows out from the substrate processing space can be recovered. As a result, deposition of the deposit material on the first window 250 or the third window 252 is reduced, and attenuation of light in the first window 250 or the third window 252 is reduced. Furthermore, wear of the first window 250 or the third window 252 is reduced, and light passes through the first window 250 or the third window 252 stably. As a result, the detector 201 can detect light sufficiently and stably. Furthermore, a replacement cycle and a lifespan of the first window 250 or the third window 252 are extended.

[0074]

In one embodiment, as illustrated in Figures 12 and 13, the lattice structure body 254 may be placed to surround a space overlapping with the first window 250 when the first window 250 is viewed from the second window 251. For example, the lattice structure body 254 may be placed in an annular shape along the sidewall 350a that forms the opening OP1 of the frame 253, and may be placed to form a space OP2 in the center where there is no lattice structure 254. According to this example, a reaching rate of light to the detector 201 from the plasma processing space 10s is improved. The lattice structure body 254 is not placed on an entire circumference along the sidewall 350a of the frame 253, but may be placed on a part of the circumference.

[0075]

The exemplary embodiments described above are applied to the capacitively coupled plasma processing apparatus, but are not limited thereto and may be applied to another plasma processing apparatus. For example, the exemplary embodiments may be applied to an inductively coupled plasma processing apparatus instead of the capacitively coupled plasma processing apparatus.

[0076]

In the embodiments described above, the plasma processing apparatus 1 is described as an example, but the embodiments are not limited thereto. For example, the embodiments may also be applied to a substrate processing apparatus that does not use plasma. In this case, the substrate processing apparatus includes a chamber having a substrate processing space and a viewport attached to the chamber, in which the viewport includes a frame defining a first space communicating with the substrate processing space, a first window, and a lattice structure body placed between the first window and the substrate processing space in the first space.

[0077]

In one embodiment, the substrate processing apparatus may have a lattice structure body in addition to the viewport. In this case, the substrate processing apparatus includes a chamber having a substrate processing space, a member having a first space communicating with the substrate processing space, and a lattice structure body placed in the first space. For example, as illustrated in Figure 14, the plasma processing apparatus 1 has a gas exhaust port 10e as a member having a first space communicating with the plasma processing space 10s and an exhaust system 40, and a lattice structure body 400 may be placed at the gas exhaust port 10e. The lattice structure body 400 may be the same as the lattice structure 254 illustrated in Figures 6 to 11. In one embodiment, for example, the plasma processing apparatus 1 may have a tube or a recess as a member having a first space communicating with the plasma processing space 10s and a measuring instrument such as a pressure gauge communicating with the first space, and a lattice structure body may be placed in the tube or the recess.

[0078]

Embodiments of the present disclosure further include the following aspects.

[0079] (Aspect 1)

A plasma processing apparatus including:

a chamber having a plasma processing space; and

a plasma viewport attached to the chamber,

in which the plasma viewport includes:

a first window;

a second window placed between the first window and the plasma processing space;

a third window placed between the first window and the second window; and

a lattice structure body placed between the second window and the third window.

[0080] (Aspect 2)

The plasma processing apparatus according to Aspect 1, in which the first window includes a quartz material.

[0081] (Aspect 3)

The plasma processing apparatus according to Aspect 1 or 2, in which the third window includes a sapphire material.

[0082] (Aspect 4)

The plasma processing apparatus according to any one of Aspects 1 to 3, in which the second window has multiple through-holes communicating with the plasma processing space.

[0083] (Aspect 5)

The plasma processing apparatus according to any one of Aspects 1 to 4, in

which the lattice structure body includes a ceramic material or an anodized aluminum material.

[0084] (Aspect 6)

The plasma processing apparatus according to any one of Aspects 1 to 5, in which the lattice structure body has a porosity of 1% to 90%.

[0085] (Aspect 7)

The plasma processing apparatus according to any one of Aspects 1 to 6, in which the lattice structure body has at least one lattice structure selected from the group consisting of Octapeak, BiTriangle, Dodecahedron, QuadDiametral, Star, and TriDiametral.

[0086] (Aspect 8)

The plasma processing apparatus according to any one of Aspects 1 to 7, in which the lattice structure body is placed to overlap with the first window when the first window is viewed from the second window.

[0087] (Aspect 9)

The plasma processing apparatus according to any one of Aspects 1 to 8, in which the lattice structure body is placed to surround a space overlapping with the first window when the first window is viewed from the second window.

[0088] (Aspect 10)

A substrate processing apparatus including:

a chamber having a substrate processing space; and

a viewport attached to the chamber,

In which the viewport includes:

A frame defining a first space communicating with the substrate processing space;

A first window; and

A lattice structure body placed between the first window and the substrate processing space in the first space.

[0089] (Aspect 11)

The substrate processing apparatus according to Aspect 10, in which the first window includes a material selected from the group consisting of quartz, sapphire, YAG, and Y_2O_3.

[0090] (Aspect 12)

The substrate processing apparatus according to Aspect 10 or 11, in which the lattice structure body includes a ceramic material or an anodized aluminum material.

[0091] (Aspect 13)

The substrate processing apparatus according to any one of Aspects 10 to 12, in which the lattice structure body has a porosity of 1% to 90%.

[0092] (Aspect 14)

The substrate processing apparatus according to any one of Aspects 10 to 13, in which the lattice structure body has at least one lattice structure selected from the group consisting of Octapeak, BiTriangle, Dodecahedron, QuadDiametral, Star, and TriDiametral.

[0093] (Aspect 15)

A substrate processing apparatus including:

A chamber having a substrate processing space;

A member having a first space communicating with the substrate processing space; and

A lattice structure body placed in the first space.

[0094] (Aspect 16)

The substrate processing apparatus according to Aspect 15, further including: an exhaust system communicating with the substrate processing space via the first space.

[0095] (Aspect 17)

The substrate processing apparatus according to Aspect 15 or 16, in which the lattice structure body includes a ceramic material or an anodized aluminum material.

[0096] (Aspect 18)

The substrate processing apparatus according to any one of Aspects 15 to 17, in which the lattice structure body has a porosity of 1% to 90%.

[0097] (Aspect 19)

The substrate processing apparatus according to any one of Aspects 15 to 18, in which the lattice structure body has at least one lattice structure selected from the group consisting of Octapeak, BiTriangle, Dodecahedron, QuadDiametral, Star, and TriDiametral.

[0098]

Each of the embodiments described above is for illustrative purposes only and is not intended to limit the scope of the present disclosure. Each of the embodiments described above can be modified in various ways without departing from the scope and spirit of the present disclosure. For example, some components from one embodiment can be added to other embodiments. Furthermore, some components in one embodiment can be replaced with corresponding components in another embodiment.

Reference Signs List

[0099]

1 ... plasma processing apparatus

10 ... chamber

10a ... sidewall

10s ... plasma processing space

11 ... substrate support

200 ... plasma viewport

201 ... detector

250 ... first window

251 ... second window

252 ... third window

253 ... frame

254 ... lattice structure body

W ... substrate

Claims

[Claim 1] A plasma processing apparatus comprising:

A chamber having a plasma processing space; and

a plasma viewport attached to the chamber,

wherein the plasma viewport includes:

a first window;

a second window placed between the first window and the plasma processing space;

a third window placed between the first window and the second window; and

a lattice structure body placed between the second window and the third window.

[Claim 2] The plasma processing apparatus according to Claim 1, wherein the first window includes a quartz material.

[Claim 3] The plasma processing apparatus according to Claim 2, wherein the third window includes a sapphire material.

[Claim 4] The plasma processing apparatus according to Claim 3, wherein the second window has multiple through-holes communicating with the plasma processing space.

[Claim 5] The plasma processing apparatus according to any one of Claims 1 to 4, wherein the lattice structure body includes a ceramic material or an anodized aluminum material.

[Claim 6] The plasma processing apparatus according to Claim 5, wherein the lattice structure body has a porosity of 1% to 90%.

[Claim 7] The plasma processing apparatus according to Claim 6, wherein the lattice structure body has at least one lattice structure selected from the group consisting of Octapeak, BiTriangle, Dodecahedron, QuadDiametral, Star, and TriDiametral.

[Claim 8] The plasma processing apparatus according to Claim 5, wherein the lattice structure body is placed to overlap with the first window when the first window is viewed from the second window.

[Claim 9] The plasma processing apparatus according to Claim 5, wherein the lattice structure body is placed to surround a space overlapping with the first window when the first window is viewed from the second window.

[Claim 10] A substrate processing apparatus comprising:

a chamber having a substrate processing space; and

a viewport attached to the chamber,

wherein the viewport includes:

a frame defining a first space communicating with the substrate processing space;

a first window; and

a lattice structure body placed between the first window and the substrate

processing space in the first space.

[Claim 11] The substrate processing apparatus according to Claim 10, wherein the first window includes a material selected from the group consisting of quartz, sapphire, YAG, and Y_2O_3.

[Claim 12] The substrate processing apparatus according to Claim 10 or 11, wherein the lattice structure body includes a ceramic material or an anodized aluminum material.

[Claim 13] The substrate processing apparatus according to Claim 12, wherein the lattice structure body has a porosity of 1% to 90%.

[Claim 14] The substrate processing apparatus according to Claim 12, wherein the lattice structure body has at least one lattice structure selected from the group consisting of Octapeak, BiTriangle, Dodecahedron, QuadDiametral, Star, and TriDiametral.

[Claim 15] A substrate processing apparatus comprising:

a chamber having a substrate processing space;

a member having a first space communicating with the substrate processing space; and

a lattice structure body placed in the first space.

[Claim 16] The substrate processing apparatus according to Claim 15, further

comprising:

an exhaust system communicating with the substrate processing space via the first space.

[Claim 17] The substrate processing apparatus according to Claim 15 or 16, wherein the lattice structure body includes a ceramic material or an anodized aluminum material.

[Claim 18] The substrate processing apparatus according to Claim 17, wherein the lattice structure body has a porosity of 1% to 90%.

[Claim 19] The substrate processing apparatus according to Claim 17, wherein the lattice structure body has at least one lattice structure selected from the group consisting of Octapeak, BiTriangle, Dodecahedron, QuadDiametral, Star, and TriDiametral.