United States Patent Application Publication	20250259879
Kind Code	A1
Publication Date	August 14, 2025
Inventor(s)	INOUE; Seiya et al.

MEMBER FOR SEMICONDUCTOR MANUFACTURING EQUIPMENT

Abstract

A member for a semiconductor manufacturing equipment includes a ceramic substrate, wherein the ceramic substrate includes a central portion with a central portion upper surface on which a wafer is to be placed, and an outer peripheral portion with an outer peripheral portion upper surface on which a focus ring is to be placed, the outer peripheral portion being located lower than the central portion upper surface, wherein the central portion includes a central portion plug placement hole that vertically penetrates the central portion, and a central portion plug that is embedded in the central portion plug placement hole, and wherein the outer peripheral portion includes an outer peripheral portion plug placement hole that vertically penetrates the outer peripheral portion, and an outer peripheral portion plug embedded in the outer peripheral portion plug placement hole and having a lower relative permittivity than the central portion plug.

Inventors: **INOUE; Seiya (Handa-Shi, JP), KUNO; Tatsuya (Nagoya-Shi, JP)**

Applicant: **NGK INSULATORS, LTD.** (Nagoya-City, JP)

Family ID: **96660033**

Assignee: **NGK INSULATORS, LTD. (Nagoya-City, JP)**

Appl. No.: **18/967783**

Filed: **December 04, 2024**

Related U.S. Application Data

parent WO continuation PCT/JP2024/004875 20240213 PENDING child US 18967783

Publication Classification

Int. Cl.: **H01L21/687** (20060101)

U.S. Cl.:

CPC **H01L21/68757** (20130101);

Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS [0001] The present invention claims the benefit of priority to International Patent Application PCT/JP2024/4875 filed on Feb. 13, 2024 with the Japanese Patent Office, the entire contents of which are incorporated herein by reference in its entirety.

FIELD OF THE INVENTION
[0002] The present invention relates to a member for a semiconductor manufacturing equipment.
BACKGROUND OF THE INVENTION
[0003] Conventionally, members for semiconductor manufacturing equipment used for holding, temperature control, transporting, or the like of wafers have been known. These types of members for semiconductor manufacturing equipment are also called a wafer placement table, an electrostatic chuck, a susceptor, or the like. Generally, they have the function of applying electrical power for electrostatic adsorption to an internal electrode and adsorbing a wafer using electrostatic force. Some members are known that have a function of controlling the temperature of the wafer by flowing gas between the wafer placement surface and the wafer, which is the object to be adsorbed.
[0004] An example of a known member for semiconductor manufacturing equipment includes a ceramic substrate having an upper surface on which a wafer is to be placed, a gas flow passage portion that vertically penetrates the ceramic substrate, and a conductive base plate bonded to the lower surface of the ceramic substrate. During wafer processing, a cooling gas such as helium gas is introduced to the back surface of the wafer through the gas flow passage.
[0005] In such a member for a semiconductor manufacturing equipment, a large potential difference from the wafer may occur, and discharge (insulation breakdown) may occur between the wafer and the base plate via the gas flow passage portion. For this reason, various techniques for arranging plugs in a gas flow passage portion have been studied in order to suppress discharge. Plugs are often composed of porous materials. If there is no plug, for example, when gas molecules are ionized by the application of an RF voltage, the generated electrons are accelerated and collide with other gas molecules, causing a glow discharge and eventually an arc discharge. However, if there is a plug, it suppresses the discharge because the electrons hit the plug before colliding with other gas molecules.
[0006] In addition, during wafer processing, a focus ring is usually placed on the outer periphery side of the wafer for the purpose of uniform processing of the wafer. For this reason, members for a semiconductor manufacturing equipment are sometimes provided with a focus ring placement surface on the outer periphery side of the wafer placement surface. Since the focus ring is used continuously, it is thicker than a wafer from the viewpoint of its lifespan, and since the top surface of the focus ring is to be at the same height as the wafer, a focus ring placement surface is usually set at a position one step lower than the wafer placement surface.
[0007] In recent years, there has been an increasing need for wafer processing (for example, deep etching) using high-power plasma. In wafer processing using high-power plasma, a focus ring is also likely to reach high temperatures, so a member for a semiconductor manufacturing equipment has been proposed in which a gas flow passage portion penetrating in the vertical direction is provided even in the outer peripheral portion where a focus ring placement surface is located (see FIG. **8** of Patent Literature 1). With this configuration, a heat transfer gas can be supplied to the focus ring through the gas flow passage portion, thereby cooling the focus ring.

PRIOR ART

Patent Literature

[0008] [Patent Literature 1] Japanese Patent No. 5357639

SUMMARY OF THE INVENTION

[0009] As described above, in a member for a semiconductor manufacturing equipment, a technique is known in which a gas flow passage portion is provided on the outer peripheral portion where the focus ring placement surface is located, to cool the focus ring. However, if the focus ring placement surface is set at a position one step lower than the wafer placement surface, the thickness of ceramic substrate will be thinner at the outer peripheral portion where the focus ring placement surface is provided than at the central portion where the wafer placement surface is provided. As a result, the vertical length in the outer peripheral portion of the gas flow passage portion, which corresponds to the thickness of the outer peripheral portion of the ceramic substrate, is shorter, and the electric field strength during wafer processing is greater, so the risk of insulation breakdown is higher in the outer peripheral portion than in the central portion.

[0010] In view of the above circumstances, an object of one embodiment of the present invention is to provide a member for a semiconductor manufacturing equipment comprising a ceramic substrate having a central portion with a wafer placement surface and an outer peripheral portion with a focus ring placement surface, in which the member for a semiconductor manufacturing equipment has a reduced risk of insulation breakdown in the outer peripheral portion.

[0011] The present inventor has made extensive studies to solve the above problems, and has created the present invention as exemplified below.

Aspect 1

[0012] A member for a semiconductor manufacturing equipment, comprising a ceramic substrate,

[0013] wherein the ceramic substrate comprises a central portion with a central portion upper surface on which a wafer is to be placed, and an outer peripheral portion with an outer peripheral portion upper surface on which a focus ring is to be placed, the outer peripheral portion being located on an outer peripheral side of the central portion upper surface and lower than the central portion upper surface, [0014] wherein the central portion comprises a central portion plug placement hole that vertically penetrates the central portion, and a central portion plug that is embedded in the central portion plug placement hole, and [0015] wherein the outer peripheral portion comprises an outer peripheral portion plug placement hole that vertically penetrates the outer peripheral portion, and an outer peripheral portion plug embedded in the outer peripheral portion plug placement hole and having a lower relative permittivity than the central portion plug.

Aspect 2

[0016] The member for a semiconductor manufacturing equipment according to aspect 1, wherein the relative permittivity of the outer peripheral portion plug is 0.7 times or less than the relative permittivity of the central portion plug.

Aspect 3

[0017] The member for a semiconductor manufacturing equipment according to aspect 1 or 2, wherein a main component of the central portion plug is the same as a main component of the ceramic substrate.

Aspect 4

[0018] The member for a semiconductor manufacturing equipment according to any one of aspects 1 to 3, wherein the outer peripheral portion plug comprises silica.

Aspect 5

[0019] The member for a semiconductor manufacturing equipment according to any one of aspects 1 to 4, wherein the central portion plug and/or the outer peripheral portion plug is a porous body or a dense body with a flow passage passing an inside the dense body.

Aspect 6

[0020] The member for a semiconductor manufacturing equipment according to any one of aspects

1 to 5, wherein a thickness of the outer peripheral portion is 75% or less of the thickness of the central portion.
[0021] According to one embodiment of the present invention, it is possible to provide a member for a semiconductor manufacturing equipment having a reduced risk of insulation breakdown in the outer peripheral portion with a focus ring placement surface. Therefore, the member for a semiconductor manufacturing equipment is suitable for performing wafer processing (for example, deep etching) using high-power plasma, for example.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0022] FIG. **1** is a schematic partial longitudinal sectional view of a member for a semiconductor manufacturing equipment according to one embodiment of the present invention.
[0023] FIG. **2** is a schematic plan view of a member for a semiconductor manufacturing equipment according to one embodiment of the present invention.
[0024] FIGS. **3**A-**3**F show a manufacturing process diagram of a member for a semiconductor manufacturing equipment according to one embodiment of the present invention.
DETAILED DESCRIPTION OF THE INVENTION
[0025] Hereinafter, embodiments of the present invention will now be described in detail with reference to the drawings. It should be understood that the present invention is not intended to be limited to the following embodiments, and any change, improvement or the like of the design may be appropriately added based on ordinary knowledge of those skilled in the art without departing from the spirit of the present invention. In addition, as used herein, “upper” and “lower” are used to conveniently express the relative positional relationship when a member for a semiconductor manufacturing equipment is placed on a horizontal plane with the upper surface of the ceramic substrate facing upward, and they do not represent any absolute positional relationships. Therefore, depending on the orientation of the member for a semiconductor manufacturing equipment, “upper” and “lower” may become “lower” and “upper”, or “left” and “right”, or “front” and “rear”.
1. Configuration of Member for Semiconductor Manufacturing Equipment
1-1. Overall Configuration
[0026] Referring to FIGS. **1** and **2**, a member for a semiconductor manufacturing equipment **10** according to an embodiment of the present invention can be used when performing processes such as CVD and etching on a wafer W by utilizing plasma. The member for a semiconductor manufacturing equipment **10** comprises a ceramic substrate **20** which comprises a central portion **20***a* with a central portion upper surface **21** on which a wafer W is to be placed, and an outer peripheral portion **20***b* with an outer peripheral portion upper surface **27** on which a focus ring FR is to be placed, the outer peripheral portion **20***b* being located on the outer peripheral side of the central portion upper surface **21** and lower than the central portion upper surface **21**.
[0027] The central portion **20***a* comprises a central portion plug placement hole **50***a* that vertically penetrates the central portion **20***a*, and a central portion plug **55***a* that is embedded in the central portion plug placement hole **50***a*, and the outer peripheral portion **20***b* comprises an outer peripheral portion plug placement hole **50***b* that vertically penetrates the outer peripheral portion **20***b*, and an outer peripheral portion plug **55***b* embedded in the outer peripheral portion plug placement hole **50***b* and having a lower relative permittivity than the central portion plug **55***a*.
[0028] Further, the member for a semiconductor manufacturing equipment **10** also comprises a base plate **30** that is located on the side of the lower surface **23** of the ceramic substrate **20** and has an internal refrigerant passage **32**. The ceramic substrate **20** and the base plate **30** can be bonded together via a bonding layer **40**.
1-2. Ceramic Substrate

[0029] The ceramic substrate **20** can be made of a ceramic material such as an alumina sintered body or an aluminum nitride sintered body.
[0030] The central portion **20***a* of the ceramic substrate **20** has, for example, a circular central portion upper surface **21** in a plan view (FIG. **2**). The diameter of the central portion **20***a* can be typically 190 to 450 mm, and more typically 300 to 350 mm.
[0031] A wafer W can be placed on the central portion upper surface **21**. In one embodiment, a plurality of protrusions **22** for placing the wafer W are provided over the entire surface on the central portion upper surface **21** of the ceramic substrate **20**. Although the shape of the protrusion **22** is not limited, it can be, for example, a cylinder, a prism, or the like. In addition, an annular seal band **25** may be formed along the outer edge of the central portion upper surface **21**. In this case, the wafer W may be supported by the upper end surface **21***c* of the seal band **25** and the upper end surfaces **21***a* of the plurality of protrusions **22**. It is preferable that the seal band **25** and the protrusions **22** have the same height, and the height is, for example, 5 to 100 μm, and typically 10 to 30 μm. In addition, the portion of the upper surface **21** of the ceramic substrate **20** where the seal band **21***a* and the protrusions **22** are not provided is referred to as the reference surface **21***b*.
[0032] The thickness of the central portion **20***a* of the ceramic substrate **20** is not limited, but from the viewpoint of increasing the fixing strength of the central portion plug **55***a*, it is preferably 1 mm or more. In addition, from the viewpoint of heat transfer and reducing the manufacturing cost of the ceramic substrate **20**, the thickness is preferably 5 mm or less, more preferably 3 mm or less, and even more preferably 2 mm or less. Therefore, the thickness of the central portion **20***a* is, for example, preferably 1 to 5 mm, more preferably 1 to 3 mm, and even more preferably 1 to 2 mm.
[0033] The outer peripheral portion **20***b* of the ceramic substrate **20** has, for example, an outer peripheral portion upper surface **27** having an annular shape in a plan view on the outer periphery of the central portion **20***a*. The focus ring FR can be placed on the outer peripheral portion upper surface **27**, which is one step lower than the central portion upper surface **21**.
[0034] In one embodiment, on the outer peripheral portion upper surface **27** of ceramic substrate **20**, for the purpose of placing the focus ring FR, annular seal bands **28** and **29** are formed along the inner and outer edges of outer peripheral portion upper surface **27** of ceramic substrate **20**, respectively. In this case, the focus ring FR may be supported by the upper end surfaces **27***c*, **27***a* of the seal bands **28**, **29**. The height of the seal bands **28**, **29** may be, for example, 5 to 100 μm, and typically 10 to 30 μm. In addition, the portion of the outer peripheral portion upper surface **27** of the ceramic substrate **20** on which the seal bands **28**, **29** are not provided is referred to as a reference surface **27***b*.
[0035] In one embodiment, the thickness of the outer peripheral portion **20***b* is 75% or less, preferably 60% or less, of the thickness of the central portion **20***a*. Although there is no particular lower limit for the thickness of the outer peripheral portion **20***b* relative to the thickness of the central portion **20***a*, the thickness of the outer peripheral portion **20***b* is typically 40 to 75% of the thickness of the central portion **20***a*. More typically, the thickness of the outer peripheral portion **20***b* is 50 to 60% of the thickness of the central portion **20***a*.
[0036] The lower surfaces **23** of the central portion **20***a* and the outer peripheral portion **20***b* may be flush with each other.
[0037] The central portion plug placement hole **50***a* and the outer peripheral portion plug placement hole **50***b* are a hole that vertically penetrates the ceramic substrate **20**. The central portion plug placement hole **50***a* (the outer peripheral portion plug placement hole **50***b*) is a gas flow passage from the lower surface **23** of the ceramic substrate **20** to the reference surface **21***b* of the central portion upper surface **21** (reference surface **27***b* of the outer peripheral portion upper surface **27**). The opening diameter (if the cross section of the plug placement hole is not circular, it means the equivalent circle diameter.) of the central portion plug placement hole **50***a* (the outer peripheral portion plug placement hole **50***b*) in the horizontal direction is not limited, but may be within the range of 1 to 5 mm, typically within the range of 3 to 4 mm, at any height position.

[0038] The central portion plug placement hole **50***a* (the outer peripheral portion plug placement hole **50***b*) may have the same opening diameter from top to bottom. In addition, the central portion plug placement hole **50***a* (outer peripheral portion plug placement hole **50***b*) may have a tapered inner peripheral surface **50***a***4** (inner peripheral surface **50***b***4**) whose area of the upper opening **50***a***1** (the upper opening **50***b***1**) is larger than the area of the lower opening **50***a***2** (the lower opening **50***b***2**). Therefore, the central portion plug placement hole **50***a* (the outer peripheral portion plug placement hole **50***b*) can have, for example, a cylindrical, prismatic, truncated conical or truncated pyramid space, and among these, it is preferable for it to have a truncated conical or truncated pyramid space.

[0039] Because the central portion plug placement hole **50***a* (the outer peripheral portion plug placement hole **50***b*) has a tapered inner peripheral surface **50***a***4** (the inner peripheral surface **50***b***4**), when embedding the central portion plug **55***a* (the outer peripheral portion plug **55***b*) in the central portion plug placement hole **50***a* (the outer peripheral portion plug placement hole **50***b*), the central portion plug **55***a* (the outer peripheral portion plug **55***b*) becomes likely to stop at a predetermined height position in the central portion plug placement hole **50***a* (the outer peripheral portion plug placement hole **50***b*), and as a result, an effect can be achieved that the central portion plug **55***a* (the outer peripheral portion plug **55***b*) can be embedded in the central portion plug placement hole **50***a* (the outer peripheral portion plug placement hole **50***b*) with high positioning accuracy. Further, while the central portion plug **55***a* (the outer peripheral portion plug **55***b*) becomes difficult to come out downward, it becomes relatively easy to come out upward, so that the effect of making it easy to replace the central portion plug **55***a* (the outer peripheral portion plug **55***b*) can be obtained. Furthermore, since the creepage distance becomes longer, an effect of suppressing discharge can also be obtained.

[0040] A plurality of central portion plug placement holes **50***a* (four in FIG. **2**) are provided, and a plurality of outer peripheral portion plug placement holes **50***b* (eight in FIG. **2**) are also provided. The locations of the central portion plug placement holes **50***a* and the outer peripheral portion plug placement holes **50***b* may be appropriately set in consideration of uniform gas supply to the entire back surface of the wafer W and the entire back surface of the focus ring FR. For example, it is preferable that the central portion plug placement holes **50***a* and the outer peripheral portion plug placement holes **50***b* are provided at equal intervals in the peripheral direction. There is no particular limitation on the method for fixing the central portion plug **55***a* (the outer peripheral portion plug **55***b*) to the central portion plug placement hole **50***a* (the outer peripheral portion plug placement hole **50***b*), and for example, the outer peripheral surface **55***a***4** (the outer peripheral surface **55***b***4**) of the central portion plug **55***a* (the outer peripheral portion plug **55***b*) and the inner peripheral surface **50***a***4** (the inner peripheral surface **50***b***4**) of the central portion plug placement hole **50***a* (the outer peripheral portion plug placement hole **50***b*) may be fixed so as to directly fit together. An example of a direct fitting method is to press-fit the central portion plug **55***a* (the outer peripheral portion plug **55***b*) into the central portion plug placement hole **50***a* (the outer peripheral portion plug placement hole **50***b*) to embed the plug.

[0041] It is preferable that the central portion plug **55***a* (the outer peripheral portion plug **55***b*) has an outer shape that is the same as that of the central portion plug placement hole **50***a* (the outer peripheral portion plug placement hole **50***b*) (for example, cylindrical, prismatic, truncated cone, or truncated pyramid). In this case, in order to obtain the desired fixation strength, it is preferable that the cross-sectional diameter in the horizontal direction at any height position of the central portion plug **55***a* (the outer peripheral portion plug **55***b*) is made slightly larger (for example, by about 5 to 20 μm in equivalent circle diameter) than the horizontal cross-sectional diameter of the central portion plug placement hole **50***a* (the outer peripheral portion plug placement hole **50***b*) located at the same height position. Further, as a direct fitting method, there is also a method in which a male threaded portion provided on the outer peripheral surface **55***a***4** (the outer peripheral surface **55***b***4**) of the central portion plug **55***a* (the outer peripheral portion plug **55***b*) is screwed into a female threaded portion provided on the inner peripheral surface **50*a*4** (the inner peripheral surface **50*b*4**) of the central portion plug placement hole **50*a*** (the outer peripheral portion plug placement hole **50*b***). Furthermore, the outer peripheral surface **55*a*4** (the outer peripheral surface **55*b*4**) of the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) may be bonded to the inner peripheral surface **50*a*4** (the inner peripheral surface **50*b*4**) of the central portion plug placement hole **50*a*** (the outer peripheral portion plug placement hole **50*b***) via an adhesive. However, when using an adhesive for fixing, the adhesive is likely to wear out or deteriorate, resulting in a decrease in the fixing strength of the central potion plug **55*a*** (the outer peripheral potion plug **55*b***). Therefore, it is preferable to adopt a direct fitting method. If the two are directly fitted, no gap will be created between the central potion plug **55*a*** (the outer peripheral portion plug **55*b***) and the central portion plug placement hole **50*a*** (the outer peripheral portion plug placement hole **50*b***) caused by deterioration due to corrosion or erosion of the adhesive. Therefore, there is an advantage that discharge and falling off of the plugs due to deterioration of the adhesive can be prevented.

[0042] The height position of the upper surface **55*a*1** (the upper surface **55*b*1**) of the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) is not limited. Therefore, it may be set to the same height as the reference surface **21*b*** (the reference surface **27*b***) of the ceramic substrate **20**, or may be set to a different height. However, it is preferable that the height position of the upper surface **55*a*1** (the upper surface **55*b*1**) of the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) be the same height as the reference surface **21*b*** (the reference surface **27*b***). When the upper surface **55*a*1** (upper surface **55*b*1**) of the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) is made lower than the reference surface **21*b*** (the reference surface **27*b***), it is preferable to place it at a lower position within a range of 0.5 mm or less (preferably 0.2 mm or less, and more preferably 0.1 mm or less) in order to suppress the occurrence of discharge. When the upper surface **55*a*1** (the upper surface **55*b*1**) of the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) is made higher than the reference surface **21*b*** (the reference surface **27*b***), there is no particular restriction as long as it is made lower than the upper end surface **21*a*** (the upper end surfaces **27*c***, **27*a***) of the protrusion **22** (the seal band **28** and seal band **29**) and the outflow of the gas from the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) is not hindered.

[0043] There is no particular restriction on the height position of the lower surface **55*a*2** (the lower surface **55*b*2**) of the central portion plug **55*a*** (the outer peripheral portion plug **55*b***), and the lower surface **55*a*2** (the lower surface **55*b*2**) may be the same height as the lower surface **23** of the ceramic substrate **20**, or may be a different height. For example, the lower surface **55*a*2** (the lower surface **55*b*2**) of the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) may protrude below the lower surface **23** of the ceramic substrate **20**, or the lower surface **55*a*2** (the lower surface **55*b*2**) of the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) may be located above the lower surface **23** of the ceramic substrate **20**. However, in either case, it is preferable that at least a part of the lower surface **55*a*2** (the lower surface **55*b*2**) contacts a bonding layer **40** from the viewpoint of suppressing discharge.

[0044] As can be seen from FIG. **1**, the outer peripheral portion upper surface **27** constituting the focus ring placement surface is set at a position one step lower than the central portion upper surface **21** constituting the wafer placement surface, and the thickness of ceramic substrate **20** is thinner at the outer peripheral portion **20*b*** than at the central portion **20*a***. Therefore, during wafer processing, a greater electric field strength is applied to the outer peripheral portion plug **55*b*** embedded in the outer peripheral portion plug placement hole **50*b*** than to the central portion plug **55*a*** embedded in the central portion plug placement hole **50*a***. However, since the outer peripheral portion plug **55*b*** has a lower relative permittivity than the central portion plug **55*a***, the voltage drop in the outer peripheral portion plug **55*b*** is promoted, thereby suppressing a sudden voltage drop near the lower surface of the outer peripheral portion plug **55*b*** and making it less likely for insulation breakdown to occur. Although it is not intended that the present invention be limited by any theory, such a mechanism can reduce the risk of insulation breakdown at the outer peripheral portion of the focus ring.

[0045] The above mechanism will be specifically described below. The central portion plug **55**_a_ and the outer peripheral portion plug **55**_b_ can each be regarded as a pseudo-capacitor. In this case, the capacitance C1 of the central portion plug **55**_a_ can be roughly calculated by the following formula A. The capacitance C2 of the outer peripheral portion plug **55**_b_ can be roughly calculated by the following formula B.

[00001] $C_1 = ({}_0 \times {}_{r1} \times S_1) / d_1$ Formula$A$

(in which, ε.sub.0 represents the relative permittivity of vacuum, ε.sub.r1 represents the relative permittivity of the central portion plug **55**_a_, S.sub.1 represents the area of the upper surface **55**_a_**1** of the central portion plug **55**_a_, and d.sub.1 represents the thickness of the central portion **20**_a_≈the thickness of the central portion plug **55**_a_.)

[00002] $C_2 = ({}_0 \times {}_{r2} \times S_2) / d_2$ Formula$B$

(in which, ε.sub.0 represents the relative permittivity of vacuum, ε.sub.r2 represents the relative permittivity of the outer peripheral portion plug **55**_b_, S.sub.2 represents the area of the upper surface **55**_b_**1** of the outer peripheral portion plug **55**_b_, and d.sub.2 represents the thickness of the outer peripheral portion **20**_b_≈the thickness of the outer peripheral portion plug **55**_b_.)

[0046] Accordingly, for example, when the thickness of the outer

[0047] peripheral portion **20**_b_ is half the thickness of the central portion **20**_a_ (that is, d.sub.2=0.5×d.sub.1), and the area of the upper surface **55**_a_**1** of the central portion plug **55**_a_ is the same as the area of the upper surface **55**_b_**1** of the outer peripheral portion plug **55**_b_ (S.sub.1=S.sub.2), if the relative permittivity of the outer peripheral portion plug **55**_b_ and the central portion plugs **55** are set to be the same (ε.sub.r1=ε.sub.r2), the capacitance of the outer peripheral portion plug **55**_b_ becomes twice that of the central portion plug **55**_a_, and the voltage drop in the outer peripheral portion plug **55**_b_ becomes smaller. As a result, a sudden voltage drop is likely to occur near the lower surface **55**_b_**2** of the outer peripheral portion plug **55**_b_, increasing the risk of insulation breakdown.

[0048] In contrast, when the thickness of the outer peripheral portion **20**_b_ is half the thickness of the central portion **20**_a_ (that is, d.sub.2=0.5×d.sub.1), and the area of the upper surface **55**_a_**1** of the central portion plug **55**_a_ is the same as the area of the upper surface **55**_b_**1** of the outer peripheral portion plug **55**_b_ (S.sub.1=S.sub.2), if the relative permittivity of the outer peripheral portion plug **55**_b_ is set to half that of the central portion plug **55**_a_ (ε.sub.r2=0.5×ε.sub.r1), the electrostatic capacitance of the central portion plug **55**_a_ and the outer peripheral portion plug **55**_b_ can be made approximately the same. As a result, the voltage drops in the outer peripheral portion plug **55**_b_ and the central portion plug **55**_a_ become approximately the same, so that a sudden voltage drop near the lower surface of the outer peripheral portion plug **55**_b_ is suppressed. In this way, the risk of insulation breakdown near the lower surface **55**_b_**2** of the outer peripheral portion plug **55**_b_ can be reduced compared to the case where ε.sub.r1=ε.sub.r2.

[0049] From the viewpoint of enhancing the effect of reducing the risk of insulation breakdown in the outer peripheral portion **20**_b_ of the ceramic substrate **20**, the relative permittivity of the outer peripheral portion plug **55**_b_ is preferably 0.7 times or less, and more preferably 0.5 times or less of the relative permittivity of the central portion plug **55**_a_. Although no particular lower limit is set for the relative permittivity of the outer peripheral portion plug **55**_b_, it is also affected by the ratio of the thickness of the central portion **20**_a_ to that of the outer peripheral portion plug **55**_b_. Considering the typical ratio of the thickness of the outer peripheral portion plug **55**_b_ to that of the central portion **20**_a_ and the ease of control of the relative permittivity, the relative permittivity of the outer peripheral portion plug **55**_b_ is preferably 0.2 to 0.7 times, more preferably 0.2 to 0.5 times as high as the relative permittivity of the central portion plug **55**_a_.

[0050] In one embodiment, the central portion plug **55**_a_ has a relative permittivity of 7 or more, and the outer peripheral portion plug **55***b* has a relative permittivity of 5 or less. In a preferred embodiment, the central portion plug **55***a* has a relative permittivity of 7 or more, and the outer peripheral portion plug **55***b* has a relative permittivity of 4 or less. In a more preferred embodiment, the central portion plug **55***a* has a relative permittivity of 10 or more, and the outer peripheral portion plug **55***b* has a relative permittivity of 4 or less. Illustratively, the central portion plug **55***a* has a relative permittivity of 7 to 12, and the outer peripheral portion plug **55***b* has a relative permittivity of 2 to 5. Typically, the central portion plug **55***a* has a relative permittivity of 7 to 10,and the outer peripheral portion plug **55***b* has a relative permittivity of 3 to 4.

[0051] As used herein, the relative permittivity of the plugs, such as the central portion plug **55***a* and the outer peripheral portion plug **55***b*, is measured by removing the plug from the ceramic substrate and sandwiching the upper surface and the lower surface of the plug between a pair of electrodes and using an impedance analyzer (for example, an impedance analyzer 4291A manufactured by Keysight Technologies) at a room temperature and in a normal humidity environment. As described later, the plug may be constructed by stacking a plurality of plugs made of different materials. In this case, the relative permittivity of the plug is the value of the entire plug measured according to the above-described method.

[0052] The material constituting the central portion plug **55***a* and the outer peripheral portion plug **55***b* may be ceramic, and may contain, for example, one or more selected from aluminum oxide, aluminum nitride, silicon carbide, silica, yttria, and zirconia. They may also be composed of only one or two selected from aluminum oxide, aluminum nitride, silica, yttria, and zirconia excluding impurities.

[0053] Among these, the central portion plug **55***a* is preferably made of a material with high corrosion resistance since it is often exposed to corrosive gases. Therefore, it is preferable that the central portion plug **55***a* contain one or more selected from aluminum oxide, aluminum nitride, yttria, and zirconia, and it is more preferable that the central portion plug **55***a* is composed of one or two selected from aluminum oxide and aluminum nitride excluding impurities, and it is even more preferable that the central portion plug **55***a* is composed of aluminum oxide excluding impurities.

[0054] Furthermore, the main component of the central portion plug **55***a* is preferably the same as the main component of the ceramic substrate **20** in order to make the coefficient of thermal expansion closer to each other and maintain the fixing strength of the plug. Here, the term “main component” refers to a component that occupies 50% by mass or more of the target object. For example, if the main component of the ceramic substrate **20** is aluminum oxide, it is preferable that the main component of the central portion plug **55***a* is also aluminum oxide.

[0055] On the other hand, since the outer peripheral portion plug **55***b* is isolated from the corrosive gas by the focus ring, there is little need to consider corrosion resistance. For this reason, it is preferable to select a material that has a low relative permittivity, and therefore it is preferable that the outer peripheral portion plug **55***b* contains silica. Further, from the viewpoint of balancing the demand for lowering the relative elative permittivity and the demand for making the coefficient of thermal expansion closer to that of the ceramic substrate, it is more preferable for the material to contain silica and aluminum oxide. Furthermore, the outer peripheral portion plug **55***b* may be made of silica excluding impurities, or may be made of silica and aluminum oxide excluding impurities. An example of silica is quartz. Therefore, it is preferable that the outer peripheral portion plug **55***b* be made of quartz and aluminum oxide excluding impurities, or be made of quartz excluding impurities.

[0056] Each of the central portion plug **55***a* and the outer peripheral portion plug **55***b* can also be constructed by stacking a plurality of plugs made of different materials in the vertical direction. In this case, the upper plug can be made of a ceramic with a higher volume resistivity than the lower plug, and the lower plug can be brought into contact with a base plate or an electrical conductor, thereby lowering the potential of the lower plug and suppressing discharge in the lower side, where

there is a large space and discharge is more likely to occur. Specifically, the central portion plug **55***a* may have an upper plug made of aluminum oxide and a lower plug made of silicon carbide, which may be arranged sequentially in the plug placement hole, while the outer peripheral portion plug **55***b* may have an upper plug made of aluminum oxide and a lower plug made of quartz, which may be arranged sequentially in the plug placement hole.
[0057] The central portion plug **55***a* and the outer peripheral portion plug **55***b* have gas flow passages **55***a***3** and **55***b***3** that penetrate the inside thereof, respectively. In one embodiment, the central portion plug **55***a* has a structure in which gas flowing in from a lower surface **55***a***2** of the central portion plug **55***a* flows through the gas flow passage **55***a***3** and flows out from the upper surface **55***a***1** of the central portion plug **55***a*. In addition, in one embodiment, the outer peripheral portion plug **55***b* has a structure in which gas flowing in from the lower surface **55***b***2** of the outer peripheral portion plug **55***b* flows through the gas flow passage **55***b***3** and flows out from the upper surface **55***b***1** of the outer peripheral portion plug **55***b*.
[0058] In one embodiment, in the central portion plug **55***a*, one or more gas flow passages **55***a***3** may be formed by vertically penetrating a dense body that does not allow gas flow. In addition, in the outer peripheral portion plug **55***b*, one or more gas flow passage **55***b***3** may be formed by vertically penetrating a dense body that does not allow gas flow. The gas flow passage **55***a***3** (the gas flow passage **55***b***3**) may be configured with any of straight lines, curved lines, or a combination of both, but rom the viewpoint of suppressing discharge, it is preferable to have a shape such that the length of the flow path is longer than the thickness (length in the vertical direction) of the central portion plug **55***a* (the outer peripheral portion plug **55***b*), for example, a curved shape such as a spiral or zigzag shape. The fact that the central portion plug **55***a* (the outer peripheral portion plug **55***b*) is a dense body means that the porosity of the central portion plug **55***a* (the outer peripheral portion plug **55***b*) is 5% or less. In this case, the porosity of the central portion plug **55***a* (the outer peripheral portion plug **55***b*) is preferably 1% or less, and more preferably 0.5% or less.
[0059] Therefore, in one embodiment of the present invention, the central portion plug **55***a* is made of dense alumina and has one or more gas flow passages **55***a***3** formed inside it, and the outer peripheral portion plug **55***b* is a dense body made of quartz and has one or more gas flow passages **55***b***3** formed inside it.
[0060] The porosity of the plugs such as the central portion plug **55***a* and the outer peripheral portion plug **55***b* is measured by the following method. The plug is cut such that a cross section passing through the central axis extending in the vertical direction of the plug is exposed. Next, the portion of the cross section excluding the gas passage is observed using a scanning electron microscope (SEM) at a magnification of 3000 times in approximately 2200 μm.sup.2, and the area ratio of pores confirmed in the portion is calculated. Specifically, by analyzing the SEM image, a threshold value is determined from the luminance distribution of luminance data of pixels in the image using a discriminant analysis method (Otsu's binarization). Thereafter, each pixel in the image is binarized into solid portions and pore portions based on the determined threshold value, and the area of the solid portions and the area of the pore portions are calculated. Then, the ratio of the area of the pores to the total area (the total area of the solid portions and the pore portions) is determined. The same measurements are performed at five locations on the same plug, and the average value of the measurements at five locations is taken as the porosity of the plug.
[0061] As a method of manufacturing the plug having a gas flow passage in a dense body, mention may be made to a method of firing a formed body formed using additive manufacturing technology such as a 3D printer, and a method of firing a formed body formed by mold casting using a master mold produced by a lost-wax method, for example. Mold casting is disclosed in, for example, Japanese Patent No. 7144603.
[0062] Alternatively, the central portion plug **55***a* (the outer peripheral portion plug **55***b*) may be constituted by a porous material, which may be used as the gas flow passage **55***a***3** (the gas flow

passage **55*b*3**). In this case, gas flowing in from the lower surface **55*a*2** (the lower surface **55*b*2**) of the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) flows through the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) formed by a large number of continuous pores, and flows out from the upper surface **55*a*1** (the upper surface **55*b*1**) of the central portion plug **55*a*** (the peripheral portion plug **55*b***). Since three-dimensional (for example, three-dimensional network) continuous pores that exist within the porous material serve as gas passages, the substantial passage length within the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) becomes longer compared to the case where the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) is hollow, and an effect that electric discharge is less likely to occur can be obtained. In one embodiment, the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) may be entirely porous. In another embodiment, in the central portion plug **55*a*** (the outer peripheral portion plug **55*b***), a porous gas flow passage can be formed on the inner peripheral side of the dense outer peripheral surface **55*a*4** (the outer peripheral surface **55*b*4**). It is also possible to further form one or more gas flow passages in the porous gas flow passage.

[0063] Therefore, the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) may be hollow or porous. It is preferable that at least a portion of the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) be porous. The fact that the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) is hollow means that the porosity is 100%. The fact that the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) is porous means that the porosity of the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) is greater than 5% and less than 100%. The porosity of the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) is preferably large in order to reduce ventilation resistance. Therefore, the porosity of the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) is preferably 10% or more, more preferably 40% or more. On the other hand, the porosity of the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) is preferably 50% or less in order to lengthen the passage length of the plug **55** and ensure structural strength. Therefore, the porosity of the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) is preferably 10% or more and 50% or less, and more preferably 40% or more and 50% or less.

[0064] The porosity of the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) is measured by mercury porosimetry method (JIS R1655: 2003).

[0065] The porosity of the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) can be controlled, for example, by adjusting the content of the pore-forming material in the raw material composition before producing by firing the ceramics which they are made of. For example, in order to make the outer peripheral surface **55*a*4** (the outer peripheral surface **55*b*4**) of the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) denser, the amount of pore-forming material near the outer peripheral surface may be partially reduced or may not be used.

[0066] As used herein, when the gas flow passage **55*a*3** (the gas flow passage **55*b*3**) of the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) is porous, the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) is treated as being porous. Therefore, when the flow path penetrating the interior of the dense central portion plug **55*a*** (the outer peripheral portion plug **55*b***) is porous, the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) can be recognized as a porous body, or can also be recognized as a dense body having a flow passage penetrating the inside thereof.

[0067] An electrode **26*a*** is incorporated in the central portion **20*a*** of the ceramic substrate **20**. The electrode **26*a*** is a planar electrode used as an electrostatic electrode, and is connected to an external DC power source via a power supply member (not shown). The electrode **26*a*** is formed of a material containing, for example, W, Mo, WC, MoC, or the like. A low-pass filter may be placed in the middle of the power supply member. The power supply member is electrically insulated from the bonding layer **40** and the base plate **30**. When a DC voltage is applied to this electrode **26*a***, the wafer W is adsorbed and fixed to the wafer placement surface (specifically, the upper end surface **21*c*** of the seal band **25** and the upper end surface **21*a*** of the protrusion **22**) by electrostatic attraction force, and when the application of the DC voltage is released, the adsorption and fixation of the wafer W to the wafer placement surface is released. As the electrode **26***a*, a heater electrode (resistance heating element) may be incorporated instead of or in addition to the electrostatic electrode. In that case, a heater power source is connected to the heater electrode. One layer of electrode may be provided inside the central portion **20***a* of the ceramic substrate **20**, or two or more layers which are spaced apart from each other may be provided inside the central portion **20***a* of the ceramic substrate **20**.

[0068] An electrode **26***b* can also be incorporated in the outer peripheral portion **20***b* of the ceramic substrate **20**. The electrode **26***b* is a planar electrode used as an electrostatic electrode, and is connected to an external DC power source via a power supply member (not shown). The electrode **26***b* is formed of a material containing, for example, W, Mo, WC, MoC, or the like. A low-pass filter may be placed in the middle of the power supply member. The power supply member is electrically insulated from the bonding layer **40** and the base plate **30**. When a DC voltage is applied to this electrode **26***b*, the wafer W is adsorbed and fixed to the wafer placement surface (specifically, the upper end surface **27***c* of the seal band **28** and the upper end surface **27***a* of the seal band **29**) by electrostatic attraction force, and when the application of the DC voltage is released, the adsorption and fixation of the wafer W to the wafer placement surface is released. As the electrode **26***b*, a heater electrode (resistance heating element) such as a ring heater may be incorporated instead of or in addition to the electrostatic electrode. In that case, a heater power source is connected to the heater electrode. One layer of electrode may be provided inside the outer peripheral portion **20***b* of the ceramic substrate **20**, or two or more layers which are spaced apart from each other may be provided inside the outer peripheral portion **20***b* of the ceramic substrate **20**.

1-3. Base Plate

[0069] In one embodiment, the base plate **30** is a circular plate (having a diameter equal to or larger than that of the outer peripheral portion **20***b* of the ceramic substrate **20**) with good electrical conductivity and thermal conductivity. Examples of the material of the base plate **30** include metal materials and composite materials of metal and ceramics. Examples of the metal material include Al, Ti, Mo, W, and alloys thereof. Examples of composite materials of metal and ceramics include metal matrix composites (MMC) and ceramic matrix composites (CMC). Specific examples of such composite materials include materials containing Si, SiC, and Ti (also referred to as SiSiCTi), materials in which porous SiC is impregnated with Al and/or Si, and composite materials of Al.sub.2O.sub.3 and TiC. A material in which a porous SiC body is impregnated with Al is called AlSiC, and a material in which a porous SiC body is impregnated with Si is called SiSiC. It is preferable to select a material for the base plate **30** that has a coefficient of thermal expansion close to that of the material for the ceramic substrate **20**. For example, when the ceramic substrate **20** is made of alumina, the base plate is preferably made of SiSiCTi or AlSiC.

[0070] Inside the base plate **30**, a refrigerant passage **32** through which refrigerant circulates may be formed. The refrigerant flowing through the refrigerant passage **32** is preferably liquid and preferably electrically insulating. Examples of the electrically insulating liquid include fluorine-based inert liquids. The refrigerant passage **32** can be formed, for example, in a single stroke across the entire base plate **30** from one end (inlet) to the other end (outlet) in a plan view. A supply port and a recovery port of an external refrigerant device (not shown) are connected to the one end and the other end of the refrigerant passage **32**, respectively. The refrigerant supplied from the supply port of the external refrigerant device to the one end of the refrigerant passage **32** passes through the refrigerant passage **32** and then returns from the other end of the refrigerant passage **32** to a recovery port of the external refrigerant device, and after the temperature has been adjusted, the refrigerant is again supplied to the one end of the refrigerant passage **32** from the supply port. The base plate **30** is connected to a radio frequency (RF) power source and can also be used as an RF electrode.

[0071] The base plate **30** may have a gas supply path **60***a* for supplying gas to the gas flow passage

55*a*3 of the central portion plug **55*a***. In addition, the base plate **30** may also have a gas supply path **60*b*** for supplying gas to the gas flow passage **55*b*3** of the outer peripheral portion plug **55*b***. There are no particular limitations on the configuration of the gas supply paths **60*a*** and **60*b***. For example, as shown in FIG. **1**, the gas supply path **60*a*** may have a recess **61*a*** provided in the upper surface **31** of the base plate **30**, and a gas introduction portion **62*a*** that supplies the gas introduced from the lower surface **33** of the base plate **30** to the recess **61*a***. In this case, when the recess **61*a*** is covered with the bonding layer **40**, the bonding layer **40** serves as the upper wall of the gas supply path **60*a***. The gas supply path **60*b*** may have the same structure. The gas supply path **60*a*** and the gas supply path **60*b*** may be in communication with each other. Alternatively, the gas supply path **60*a*** and the gas supply path **60*b*** may be configured such that the gas flows independently.

[0072] As shown in FIG. **1**, the upper surface **31** of the base plate **30** is bonded to the lower surface **23** of the ceramic substrate **20** via a bonding layer **40**. The bonding layer **40** is formed by, for example, TCB (thermal compression bonding). TCB is a known method in which a metal bonding material is sandwiched between two members to be bonded, and the two members are pressure bonded while being heated to a temperature no higher than the solidus temperature of the metal bonding material. The bonding layer **40** can be composed of a metal bonding layer using, for example, an Al-Mg-based bonding material or an Al—Si—Mg-based bonding material. The bonding layer **40** may be a layer formed of solder or a metal brazing material. Furthermore, the bonding layer **40** may be composed of a resin adhesive layer instead of the metal bonding layer. Examples of the material for the resin adhesive layer include silicone resin-based adhesives, epoxy resin-based adhesives, and acrylic resin-based adhesives. In order to improve the uniformity of the thickness of the resin adhesive layer, a spacer (not shown) may be placed between the upper surface **31** of the base plate **30** and the lower surface **23** of the ceramic substrate **20**.

[0073] The bonding layer **40** has a through hole **42*a*** which communicates with the gas flow passage **55*a*3** of the central portion plug **55*a*** and also communicates with a gas supply path **60*a*** for supplying gas to the gas flow passage **55*a*3** of the central portion plug **55*a***. In addition, the bonding layer **40** also has a through hole **42*b*** which communicates with the gas flow passage **55*b*3** of the outer peripheral portion plug **55*b*** and also communicates with a gas supply path **60*b*** for supplying gas to the gas flow passage **55*b*3** of the outer peripheral portion plug **55*b***.

[0074] A plurality of through holes **42*a*** (through holes **42*b***) may be provided for one central portion plug **55*a*** (the outer peripheral portion plug **55*b***), and in this case, it is preferable that the plurality of through holes **42*a*** (through holes **42*b***) be provided point-symmetrically with respect to the central axis of the central portion plug **55*a*** (the outer peripheral portion plug **55*b***) extending in the vertical direction. Providing a plurality of through holes **42*a*** (through holes **42*b***) can reduce the size of each through hole **42*a*** (through hole **42*b***) rather than using one large through hole **42*a*** (through hole **42*b***), thereby reducing the risk of electrical discharge. Further, by providing a plurality of through holes **42*a*** (through holes **42*b***), a necessary gas flow rate can be ensured.

[0075] Further, a lift pin hole may be provided that penetrates the member for a semiconductor manufacturing equipment **10**. The lift pin hole is a hole through which a lift pin for moving the wafer W up and down with respect to the central portion upper surface **21** of the ceramic substrate **20** is inserted. Lift pin holes are provided, for example, at three locations when the wafer W is supported by three lift pins.

2. How to use a Member for Semiconductor Manufacturing Equipment

[0076] Next, a method of using the member for a semiconductor manufacturing equipment **10** thus configured will be exemplified. First, with the member for a semiconductor manufacturing equipment **10** installed in a chamber (not shown), a focus ring FR is placed on outer peripheral portion upper surface **27** of ceramic substrate **20**, and wafer W is placed on central portion upper surface **21** of ceramic substrate **20**. Then, the pressure inside the chamber is reduced with a vacuum pump and adjusted to the desired degree of vacuum, and a voltage is applied to the electrode **26*a*** and electrode **26*b*** of the ceramic substrate **20** to generate electrostatic adsorption force, and the wafer W is adsorbed and fixed to the wafer placement surface (specifically, the upper end surface **21***c* of the seal band **25** and the upper end surface **21***a* of the protrusion **22**), and the focus ring FR is adsorbed and fixed to the focus ring placement surface (specifically, the upper end surface **27***c* of the seal band **28** and the upper end surface **27***a* of the seal band **29**).

[0077] Next, the inside of the chamber is set to a reaction gas atmosphere at a predetermined pressure (for example, several tens to several hundreds of Pa), and in this state, a high frequency voltage such as an RF voltage is applied between an upper electrode (not shown) provided on the ceiling of the chamber and the base plate **30** of the member for a semiconductor manufacturing equipment **10** to generate plasma. A refrigerant circulates in the refrigerant passage **32** of the base plate **30**. Backside gas is introduced into the gas supply path **60***a* and the gas supply path **60***b* from a gas cylinder (not shown). The backside gas passes through the gas supply path **60***a* and the plurality of central portion plugs **55***a* and is supplied and enclosed in the space between the back surface of the wafer W and the reference surface **21***b* of the wafer placement surface. Similarly, the backside gas passes through a gas supply path **60***b* and a plurality of outer peripheral portion plugs **55***b*, and is supplied and enclosed in the space between the back surface of the focus ring FR and the reference surface **27***b* of the focus ring placement surface. The presence of this backside gas allows efficient thermal conduction between the wafer W and the ceramic substrate **20**, and between the focus ring FR and the ceramic substrate **20**.

[0078] By embedding the central portion plug **55***a* and the outer peripheral portion plug **55***b* in the central portion plug placement hole **50***a* and the outer peripheral portion plug placement hole **50***b*, respectively, discharges in the central portion plug placement hole **50***a* and the outer peripheral portion plug placement hole **50***b* can be suppressed. If the central portion plug **55***a* (the outer peripheral portion plug **55***b*) were not present, electrons generated as a result of ionization of gas molecules by application of an RF voltage would accelerate and collide with other gas molecules, causing a glow discharge and eventually an arc discharge. However, if the central portion plug **55***a* (the outer peripheral portion plug **55***b*) is present, the electrons will hit the central portion plug **55***a* (the outer peripheral portion plug **55***b*) before colliding with other gas molecules, thereby suppressing discharge.

3. Method for Manufacturing a Member for Semiconductor Manufacturing Equipment

[0079] Next, a method for manufacturing the member for a semiconductor manufacturing equipment **10** will be exemplarily described based on FIGS. **3**A-**3**F. First, a disk-shaped ceramic sintered body **120** that is the base of the ceramic substrate **20** is produced by hot-press sintering a ceramic powder formed body (FIG. **3**A). The formed body may be manufactured by laminating a plurality of tape formed bodies, by a mold casting method, or by compacting ceramic powder. An electrode **22** is provided inside the ceramic sintered body **120**.

[0080] Next, the central portion plug placement hole **50***a* and the outer peripheral portion plug placement hole **50***b* are formed in the ceramic sintered body **120** by machining. In addition, a plurality of protrusions **22** and a seal band **25** are formed by laser processing on the upper surface of the ceramic sintered body **120** (FIG. **3**B). The plurality of protrusions **22** and the seal band **25** may be formed after the ceramic substrate **20** and the base plate **30** are bonded together.

[0081] In parallel with this, two MMC disk members **131** and **136** are prepared (FIG. **3**C). When the ceramic sintered body **120** is made of alumina, it is preferable that the MMC disk members **131** and **136** be made of SiSiCTi or AlSiC. This is because the coefficient of thermal expansion of alumina is approximately the same as that of SiSiCTi and AlSiC. The MMC disk member made of SiSiCTi can be manufactured, for example, as follows. First, silicon carbide, metal Si, and metal Ti are mixed to produce a powder mixture. Next, the resulting powder mixture is uniaxially pressed to produce a disk-shaped formed body, which is then hot-press sintered in an inert atmosphere to obtain the MMC disk member made of SiSiCTi.

[0082] Then, grooves **132**, which will eventually become the refrigerant passage **32**, are formed on the lower surface of the upper MMC disk member **131** by machining. A through hole **133** for introducing the refrigerant and a through hole **134** for discharging the refrigerant are formed in the lower MMC disk member **136**. Further, grooves **160** and through holes **161**, which will become the gas supply paths **60***a* and **60***b*, are formed on the upper MMC disk member **131** and the lower MMC disk member **136** by machining (FIG. **3**D).

[0083] Next, metal bonding materials **135** and **137** are prepared. The metal bonding materials **135** and **137** preferably have a thickness of about 100 μm (for example, 80 to 240 μm). The metal bonding material **135** has a through hole **90** a for communicating the refrigerant flow passage of the lower MMC disk member **136** and that of the upper MMC disk member **131**. In addition, the metal bonding material **135** also has a through hole **90***b* for communicating the gas supply passage **60***a* (gas supply passage **60***b*) of the lower MMC disk member **136** and that of the upper MMC disk member **131**. The metal bonding material **137** has a through hole **91***a* for communicating the central portion plug placement hole **50***a* with the gas supply path **60***a*, and a through hole **91***b* for communicating the outer peripheral portion plug placement hole **50***b* with the gas supply path **60***b*.

[0084] The metal bonding material **135** is disposed between the lower surface of the upper MMC disk member **131** and the upper surface of the lower MMC disk member **136**, and the metal bonding material **137** is disposed on the upper surface of the upper MMC disk member **131**. Next, the ceramic sintered body **120** is placed on the metal bonding material **137** arranged on the top surface of the upper MMC disk member **131**. This results in a laminate **110** in which the lower MMC disk member **136**, the metal bonding material **135**, the upper MMC disk member **131**, the metal bonding material **137**, and the ceramic sintered body **120** are laminated in this order from the bottom (FIG. **3**E).

[0085] This laminate **110** is pressed while being heated (TCB) to obtain a bonded body **111** (FIG. **3**F). The bonded body **111** is formed by bonding a ceramic sintered body **120** to the upper surface of a base plate **30** via the bonding layer **40**. The base plate **30** is formed by bonding an upper MMC disk member **131** and a lower MMC disk member **136** via the bonding layer **40**. The base plate **30** has the refrigerant passage **32**, a refrigerant introduction portion **36**, a refrigerant discharge portion **38**, a gas supply path **60***a*, and a gas supply path **60***b*.

[0086] The TCB is performed, for example, as follows. That is, the

[0087] laminate is pressurized and bonded at a temperature no higher than the solidus temperature of the metal bonding material (for example, the temperature 20° C. lower than the solidus temperature or more and no higher than the solidus temperature), and then returned to room temperature. Thereby, the metal bonding material becomes the metal bonding layer. In this case, an Al—Mg based bonding material or an Al—Si—Mg based bonding material can be used as the metal bonding material. For example, when TCB is performed using an Al—Si—Mg based bonding material, the laminate is pressurized in a heated state under a vacuum atmosphere. The metal bonding material preferably has a thickness of approximately 100 μm.

[0088] Next, the outer periphery of the ceramic sintered body **120** is cut to form a step, and the seal bands **28**, **29** are formed by laser processing (FIG. **3**F), thus obtaining the ceramic substrate **20** having a central portion **20***a* and an outer peripheral portion **20***b*.

[0089] Next, the central portion plugs **55***a* and the outer peripheral portion plugs **55***b* are embedded in the central portion plug placement hole **50***a* and the outer peripheral portion plug placement hole **50***b* of the ceramic substrate **20**, respectively (FIG. **3**F). Alternatively, a paste-like ceramic mixture serving as a precursor of the central portion plug **55***a* and the outer peripheral portion plug **55***b* may be injected into the central portion plug placement hole **50***a* and the outer peripheral portion plug placement hole **50***b* of the ceramic substrate **20** and fired to form the central portion plugs **55***a* and the outer peripheral portion plugs **55***b*. Thereafter, the member for a semiconductor manufacturing equipment is completed by appropriately going through processes such as adjusting the overall shape.

[0090] In addition, although the base plate **30** in FIG. **1** is described as an integrated component, it may have a structure in which two components are bonded with a metal bonding layer as shown in

FIG. **3**F, or a structure in which three or more components are bonded with a metal bonding layer. Further, when the bonding layer **40** is formed using the metal bonding material **137**, an insulating film may be formed on the side surface of the base plate **30** by thermal spraying either before or after bonding to the ceramic substrate **20**. When a resin adhesive sheet is used to form the bonding layer **40**, an insulating film may be formed by thermal spraying before bonding to the ceramic substrate **20** in order to prevent the resin from melting.

DESCRIPTION OF REFERENCE NUMERALS

[0091] **10**: Member for semiconductor manufacturing equipment [0092] **20**: Ceramic substrate [0093] **20***a:* Central portion [0094] **20***b:* Outer peripheral portion [0095] **21**: Central portion upper surface [0096] **21***a:* Upper end surface [0097] **21***b:* Reference surface [0098] **21***c:* Upper end surface [0099] **22**: Protrusion [0100] **23**: Lower surface [0101] **25**: Seal band [0102] **26***a:* Electrode [0103] **26***b:* Electrode [0104] **27**: Outer peripheral portion upper surface [0105] **27***a:* Upper end surface [0106] **27***b:* Reference surface [0107] **27***c:* Upper end surface [0108] **28**: Seal band [0109] **29**: Seal band [0110] **30**: Base plate [0111] **31**: Upper surface [0112] **32**: Refrigerant passage [0113] **33**: Lower surface [0114] **36**: Refrigerant introduction portion [0115] **38**: Refrigerant discharge portion [0116] **40**: Bonding layer [0117] **42***a:* Through hole [0118] **42***b:* Through hole [0119] **50***a:* Central portion plug placement hole [0120] **50***a***1**: Upper opening [0121] **50***a***2**: Lower opening [0122] **50***a***4**: Inner peripheral surface [0123] **50***b:* Outer peripheral portion plug placement hole [0124] **50***b***1**: Upper opening [0125] **50***b***2**: Lower opening [0126] **50***b***4**: Inner peripheral surface [0127] **55***a:* Central portion plug [0128] **55***a***1**: Upper surface [0129] **55***a***2**: Lower surface [0130] **55***a***3**: Gas flow passage [0131] **55***a***4**: Outer peripheral surface [0132] **55***b:* Outer peripheral portion plug [0133] **55***b***1**: Upper surface [0134] **55***b***2**: Lower surface [0135] **55***b***3**: Gas flow passage [0136] **55***b***4**: Outer peripheral surface [0137] **60***a*: Gas supply path [0138] **60***b*: Gas supply path [0139] **61***a*: Recess [0140] **62***a*: Gas introduction portion [0141] **90***a*: Through hole [0142] **90***b*: Through hole [0143] **91***a*: Through hole [0144] **91***b*: Through hole [0145] **110**: Laminate [0146] **111**: Bonded body [0147] **120**: Ceramic sintered body [0148] **131**: MMC disc member [0149] **132**: Groove [0150] **133**: Through hole [0151] **134**: Through hole [0152] **135**: Metal bonding material [0153] **136**: MMC disc member [0154] **137**: Metal bonding material [0155] **160**: Groove [0156] **161**: Through hole [0157] FR: Focus ring [0158] W: Wafer

Claims

1. A member for a semiconductor manufacturing equipment, comprising a ceramic substrate, wherein the ceramic substrate comprises a central portion with a central portion upper surface on which a wafer is to be placed, and an outer peripheral portion with an outer peripheral portion upper surface on which a focus ring is to be placed, the outer peripheral portion being located on an outer peripheral side of the central portion upper surface and lower than the central portion upper surface, wherein the central portion comprises a central portion plug placement hole that vertically penetrates the central portion, and a central portion plug that is embedded in the central portion plug placement hole, and wherein the outer peripheral portion comprises an outer peripheral portion plug placement hole that vertically penetrates the outer peripheral portion, and an outer peripheral portion plug embedded in the outer peripheral portion plug placement hole and having a lower relative permittivity than the central portion plug.

2. The member for a semiconductor manufacturing equipment according to claim 1, wherein the relative permittivity of the outer peripheral portion plug is 0.7 times or less than the relative permittivity of the central portion plug.

3. The member for a semiconductor manufacturing equipment according to claim 1, wherein a main component of the central portion plug is the same as a main component of the ceramic substrate.

4. The member for a semiconductor manufacturing equipment according to claim 1, wherein the outer peripheral portion plug comprises silica.

5. The member for a semiconductor manufacturing equipment according to claim 1, wherein the central portion plug and/or the outer peripheral portion plug is a porous body, or a dense body with a flow passage passing an inside the dense body.

6. The member for a semiconductor manufacturing equipment according to claim 1, wherein a thickness of the outer peripheral portion is 75% or less of the thickness of the central portion.