TITLE OF INVENTION

PLASMA-RESISTANT STRUCTURE, PRODUCTION METHOD FOR PLASMA-RESISTANT STRUCTURE, ELECTROSTATIC CHUCK, EDGE RING, FIBER STRUCTURE, PLASMA PROCESSING DEVICE MEMBER, AND REPAIR METHOD FOR PLASMA PROCESSING DEVICE MEMBER

TECHNICAL FIELD

[0001]

The present disclosure relates to a plasma-resistant structure, a method for manufacturing a plasma-resistant structure, an electrostatic chuck, an edge ring, a fiber structure, a component for a plasma processing apparatus, and a method for repairing a component for a plasma processing apparatus.

BACKGROUND ART

[0002]

Conventionally, as a semiconductor manufacturing apparatus, an etching apparatus has been used to perform dry etching of an object by plasma. In such an etching apparatus, an electrostatic chuck is used to fix the object by using static electricity. In such an electrostatic chuck, a holding member that fixes and holds an object and a base that supports the holding member are bonded via a bonding layer, and a plasma protection layer for reducing damage to the bonding layer by plasma is bonded to the outer surface of the bonding layer (Patent Literatures 1 and 2).

CITATION LIST

PATENT LITERATURE

[0003]

Patent Literature 1: Japanese Laid-Open Patent Publication No. 2010-165776

Patent Literature 2: Japanese Laid-Open Patent Publication No. 2021-44303

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0004]

The plasma protection layers disclosed in Patent Literatures 1 and 2 are formed from thermosetting resin or elastomer, and further improvement is required from the viewpoint of plasma resistance and the like. Likewise, in a sealed space using plasma, such as that in a plasma processing apparatus, further improvements are required from the viewpoint of plasma resistance and the like in order to maintain hermeticity. Through such improvements, extended service life of electrostatic chucks, plasma processing apparatuses, and the like can be expected.

[0005]

An object of the present invention is to provide long-life plasma-resistant structures, electrostatic chucks, edge rings, fiber structures, and components for a plasma processing apparatus, as well as methods for manufacturing such plasma-resistant structures, and methods for repairing components for a plasma processing apparatus.

[0006]

Plasma-resistant structures of the present disclosure each include:

a first member;

a second member;

an intermediate member disposed between the first member and the second member; and

a plasma protection member including a fiber, and

at least one of the first member and the second member has plasma resistance, and

the plasma protection member including the fiber is disposed on an outer surface side of the respective plasma-resistant structure at an end portion of the intermediate member.

[0007]

In the plasma-resistant structures of the present disclosure,

the plasma protection member including the fiber may be disposed on an outer periphery of the intermediate member.

[0008]

In the plasma-resistant structures of the present disclosure,

a direction in which the fiber extends may be along an outer periphery of the intermediate member.

[0009]

In the plasma-resistant structures of the present disclosure,

the plasma protection member including the fiber may include a fiber structure composed of a fiber.

[0010]

In the plasma-resistant structures of the present disclosure,

a direction in which the fiber structure extends may be along an outer periphery of the intermediate member.

[0011]

In the plasma-resistant structures of the present disclosure,

the intermediate member may be a bonding layer.

[0012]

In the plasma-resistant structures of the present disclosure,

a length of the fiber in a direction in which the fiber extends may be longer than a length of an outer periphery of the intermediate member, and

the fiber may be wound around the outer periphery of the intermediate member.

[0013]

In the plasma-resistant structures of the present disclosure

a length of the fiber structure in a direction in which the fiber structure extends may be longer than a length of an outer periphery of the intermediate member, and

the fiber structure may be wound around the outer periphery of the intermediate member.

[0014]

In the plasma-resistant structures of the present disclosure,

the fiber may be an inorganic fiber.

[0015]

In the plasma-resistant structures of the present disclosure,

the fiber structure may include at least one of a twisted yarn, a nonwoven fabric, a mesh, and a woven fabric.

[0016]

Electrostatic chucks of the present disclosure each include the plasma-resistant structure of the present disclosure.

The first member is a holding member configured to hold an object to be held, and the second member is a base configured to support the holding member.

[0017]

In the electrostatic chucks of the present disclosure,

an outermost periphery of the holding member may be positioned outward of an outermost portion of the plasma protection member.

[0018]

In the electrostatic chucks of the present disclosure,

an outermost periphery of the base may be positioned outward of an outermost portion of the plasma protection member.

[0019]

Edge rings of the present disclosure each include the plasma-resistant structure of the present disclosure.

[0020]

Components for a plasma processing apparatus of the present disclosure each include the plasma-resistant structure of the present disclosure.

[0021]

Fiber structures of the present disclosure are each a fiber structure including a fiber.

In a plasma-resistant structure including a first member, a second member, an intermediate member disposed between the first member and the second member, and the fiber structure of the present disclosure, the fiber structure is disposed along an outer periphery of the intermediate member.

[0022]

Methods for manufacturing a plasma-resistant structure of the present disclosure are each

a method for manufacturing a plasma-resistant structure including a first member, a second member, an intermediate member disposed between the first member and the second member, and a fiber structure including a fiber. The method includes:

disposing the intermediate member between the first member and the second member; and

winding the fiber structure around an outer periphery of the intermediate member.

[0023]

Methods for repairing components for a plasma processing apparatus of the present disclosure are each a method for repairing a component of a plasma processing apparatus, the component including a first member, a second member, and an intermediate member disposed between the first member and the second member.

The method includes winding a fiber structure including a fiber around an outer periphery of the intermediate member.

[0024]

The present disclosure provides long-life plasma-resistant structures, electrostatic chucks, edge rings, fiber structures, and components for a plasma processing apparatus, as well as methods for manufacturing such plasma-resistant structures, and methods for repairing components for a plasma processing apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

FIG. 1 is a cross-sectional view showing a schematic configuration of a plasma-resistant structure according to an embodiment of the present disclosure.

FIG. 2 is a cross-sectional view showing another schematic configuration of the plasma-resistant structure according to the embodiment of the present disclosure.

FIG. 3 represents schematic diagrams showing a method for repairing a plasma-resistant structure (electrostatic chuck) according to an embodiment of the present disclosure.

FIG. 4 is a cross-sectional view showing a schematic configuration of an electrostatic chuck according to an embodiment of the present disclosure.

FIG. 5 is a cross-sectional view showing another schematic configuration of the electrostatic

chuck according to the embodiment of the present disclosure.

FIG. 6 is a diagram showing a schematic configuration of an edge ring according to an embodiment of the present disclosure.

FIG. 7 is a diagram showing a schematic configuration in which the edge ring is disposed so as to surround the electrostatic chuck according to the embodiment of the present disclosure.

FIG. 8 is a cross-sectional view of fiber bundles as examples of a fiber structure according to an embodiment of the present disclosure.

FIG. 9 is a cross-sectional photograph of a plasma-resistant structure according to the embodiment of the present disclosure.

FIG. 10 is a cross-sectional photograph of a plasma-resistant structure according to another embodiment of the present disclosure.

FIG. 11 is a cross-sectional photograph of a plasma-resistant structure according to still another embodiment of the present disclosure.

FIG. 12 is a cross-sectional view showing another schematic configuration of the electrostatic chuck according to the embodiment of the present disclosure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026]

Hereinafter, embodiments of the present disclosure will be described with reference to the drawings. However, the inventions according to the present disclosure are not limited to these embodiments.

[0027]

[Plasma-resistant structures]

FIG. 1 and FIG. 2 are cross-sectional views each showing a schematic configuration of a plasma-resistant structure according to an embodiment of the present disclosure. As shown in FIG. 1, a plasma-resistant structure 1 includes a first member 2, a second member 3, an intermediate member 4 disposed between the first member 2 and the second member 3, and a plasma protection member 5 including fiber(s). At least one of the first member 2 and the second member 3 has plasma resistance. The plasma protection member 5

including fiber(s) (hereinafter also simply referred to as “plasma protection member 5”) is disposed on the outer surface side of the plasma-resistant structure 1 at an end portion of the intermediate member 4. Here, the “outer surface side” of the plasma-resistant structure 1 refers to the side exposed to the external atmosphere. In FIG. 6(B) that is a cross-sectional view showing a schematic configuration of an edge ring according to an embodiment of the present disclosure, plasma protection members 45a, 45b (plasma protection members 5) are disposed on the outer and inner peripheries of an edge ring 41 (plasma-resistant structure 1) at end portions of an intermediate member 44, and both the outer and inner peripheries are located on the outer surface side of the plasma-resistant structure 1 (edge ring 41) that is in contact with the external atmosphere.

[0028]

The plasma-resistant structure 1 can be used in a plasma atmosphere during a semiconductor manufacturing process (examples of applications include semiconductor manufacturing apparatuses, plasma processing apparatuses, parts installed and used inside such apparatuses, electrostatic chucks, edge rings, upper electrodes, inner walls of such apparatuses, ventilation valves, and sealing members). Employing the plasma-resistant structure 1 for these applications improves the durability of the semiconductor manufacturing apparatus and the like, thereby enhancing the efficiency of semiconductor manufacturing processes.

[0029]

(First member 2 and second member 3)

In the plasma-resistant structure 1, at least one of the first member 2 and the second member 3 may have plasma resistance. In other words, only the first member 2 may be formed from a material having plasma resistance (plasma-resistant material), or only the second member 3 may be formed from the plasma-resistant material. Preferably, both the first member 2 and the second member 3 are formed from the plasma-resistant material, because the intermediate member 4 disposed therebetween can be more effectively protected from plasma.

[0030]

Moreover, the first member 2 and the second member 3 preferably each have such a shape

as planar, disk-like, plate-like, cubic, or columnar shape because the intermediate member 4 can be efficiently covered and more effectively protected from plasma. Each of these members may also have a structure shaped into a certain pattern (e.g., ring-shape, arc-shape, comb-shape, etc.). The first member 2 and/or the second member 3 may be the plasma protection member 5 including fiber(s) described later. Like a first member 2a of a plasma-resistant structure 1a shown in FIG. 2, the first member 2 and/or the second member 3 may be the plasma protection member 5 including fiber(s). The first member 2 and/or the second member 3 may be composed of a plurality of constituents.

[0031]

As the plasma-resistant material, organic materials and inorganic materials may be used. Examples of preferable organic materials include, but are not limited to, nylon, polyimide, polyamide, polyester, acrylic, polyolefin, aromatic polyether ketone, polyphenylene sulfide, fluororesin, polyvinyl alcohol, ethylene–vinyl alcohol resin, phenolic resin, vinyl chloride, and silicone resin. Examples of preferable inorganic materials include, but are not limited to, metals and ceramics. Examples of the inorganic materials include those including at least one of yttrium, aluminum, zirconium, hafnium, calcium, magnesium, nickel, titanium, and silicon. The inorganic materials may be oxides, hydroxides, carbides thereof or mixtures thereof (such as minerals). The mixtures may further include hydroxyapatite.

[0032]

(Intermediate member 4)

The intermediate member 4 is not particularly limited, and may have functions such as bonding (including temporary bonding that enables re-peeling), sealing, insulation, thermal control (heat insulation, heat conduction), and electrical conduction (hereinafter also referred to as “functional members”). The intermediate member 4 may be a filler or a space with no intended function. Therefore, the material for the intermediate member 4 is also not particularly limited. The shape of the intermediate member 4 is also not particularly limited, and may be hollow, laminar, disk-like, plate-like, columnar, or the like. The intermediate member 4 may be a laminate thereof, a structure shaped into a certain pattern (e.g., ring-shape, arc-shape, comb-shape, etc.) is removed, or a combination of a plurality of the above. The shape of the intermediate member 4 is preferably laminar, disk-

like, plate-like, or columnar, because such shapes can reduce the area of the intermediate member 4 exposed to a plasma atmosphere (external atmosphere). The intermediate member 4 may or may not have plasma resistance, and most of the intermediate member 4 is preferably covered with the first member 2 and the second member 3. Specifically, the area of the intermediate member 4 in contact with the first member 2 and the second member 3 is preferably at least 10 times or more larger than the area of the intermediate member 4 facing the plasma protection member 5. In this case, most of the outer surface of the plasma-resistant structure 1 has plasma resistance, thereby ensuring plasma resistance of the plasma-resistant structure 1. Specific examples of the intermediate member 4 include a sealing member (O-ring), a bonding layer (bonding layer 14 in FIG. 4), a heat insulating layer, and a heat transfer layer.

[0033]

In a case where the intermediate member 4 has an inner peripheral side (i.e., has a ring shape; such as when the plasma-resistant structure 1 is an edge ring or an electrostatic chuck 31 having a through-hole) and the inner peripheral side of the intermediate member 4 is exposed to the plasma space, the plasma protection member 5 is preferably disposed on the inner peripheral side of the ring, and the plasma protection member 5 is more preferably disposed along the inner periphery of the ring.

[0034]

(Bonding layer)

The bonding layer, which is one of the functional members, is not particularly limited, and a metal, an adhesive material (resin), or the like may be used. As for the metal, from the viewpoint of workability, a brazing filler metal (silver, copper, copper-alloy, aluminum, nickel, active silver, titanium, a solder, etc.) can be used. Any of these metals can be selected as appropriate in view of the properties (e.g., thermal expansion, thermal conductivity, etc.) of the first member 2 and the second member 3 to be bonded.

[0035]

The bonding layer may have not only a bonding function but also other functions, such as insulation, heat insulation, heat conduction, and electrical conduction.

[0036]

(Adhesive material)

The bonding layer (functional member) may be an adhesive material. Examples of the adhesive material include silicone resin, fluororesin, epoxy resin, acrylic resin, polyimide resin, polyamide resin, polyester resin, polyolefin resin, and these adhesive materials mixed with fillers. From the viewpoints of adhesion and heat resistance, silicone resin, fluororesin, acrylic resin, polyimide resin, and these adhesive materials mixed with fillers are preferred; silicone resin, acrylic resin, epoxy resin, and these mixed with fillers are more preferred; and silicone resin, and silicone resin mixed with fillers are further preferred. However, the adhesive materials are not limited thereto. Silicone resin can provide a plasma-resistant structure 1 with excellent stress relaxation properties, thereby reducing damage due to temperature change. Furthermore, silicone resin mixed with a thermally conductive filler can improve heat exchange between the first member 2 and the second member 3, and can reduce damage due to local overheating of the plasma-resistant structure 1. As a result, a plasma-resistant structure 1 with a long service life can be provided.

[0037]

(Sealing material)

The intermediate member 4 may be a sealing material (sealing member). Examples of the sealing material include silicone, polyimide, aromatic polyether ketone, fluororesin, epoxy resin, urethane resin, acrylic resin, elastomer, and these sealing materials mixed with fillers. From the viewpoints of plasma resistance and heat resistance, polyimide, fluororesin, epoxy resin, and fluororesin mixed with a thermally conductive filler are preferred. However, the sealing materials are not limited thereto. The sealing material may have a ring shape (e.g., O-ring), or may be formed by pouring an uncured curable liquid resin into a desired shape. Fluororesin mixed with a filler has excellent durability (plasma resistance, damage reduction), thereby providing a plasma-resistant structure 1 with a long service life. In this case, from the viewpoint of plasma resistance, examples of the fillers include ceramic particles; specifically, oxides, hydroxides, and carbides including at least one of yttrium, aluminum, zirconium, hafnium, calcium, magnesium, nickel, titanium, and silicon. From the viewpoints of plasma resistance and insulation, examples of the fillers include yttrium oxide, aluminum oxide, and aluminum nitride. Thus, a sealing material with excellent

plasma resistance and insulation can be provided. As a result, a plasma-resistant structure 1 with a long service life can be provided.

[0038]

The sealing material may have not only a sealing function but also other functions, such as insulation, heat insulation, heat conduction, and electrical conduction.

[0039]

(Heat insulating material)

The intermediate member 4 may be a heat insulating material. Examples of the heat insulating material include, but are not limited to, resin materials and metal materials. Examples of the resin materials include silicone, polyimide, aromatic polyether ketone, fluororesin, epoxy resin, urethane resin, acrylic resin, and elastomer. Examples of the metal materials include stainless steel. Such heat insulating materials may have voids (e.g., foams). However, the heat insulating materials are not limited thereto. A heat insulating material enables precise thermal management in the plasma-resistant structure 1, thereby reducing damage due to overheating. As a result, a plasma-resistant structure 1 with a long service life can be provided. The heat insulating material may have not only a heat insulating function but also other functions, such as bonding, insulation, and electrical conduction.

[0040]

(Plasma protection member 5)

The plasma protection member 5 includes fiber(s), and is formed from a plasma-resistant material. The plasma protection member 5 protects the intermediate member 4, such as a resin material, from the plasma space, and can isolate or distance the resin material from the plasma space. The plasma protection member 5 blocks a path from the plasma space to the intermediate member 4, and increases the distance for the plasma to reach the intermediate member 4. As such, the plasma becomes deactivated, thereby reducing adverse effects on the intermediate member 4. The plasma protection member 5 composed of fiber(s) has voids formed between and around the fiber(s), and such voids follow dimensional changes of the surroundings and can relieve stress (cushioning effect). For example, the voids follow dimensional changes of the first member 2 and the second

member 3 caused by heating and can relieve stress generated by such dimensional changes. As a result, the service life of the plasma-resistant structure 1 can be extended. Furthermore, when the plasma protection member 5 is formed by mixing fibers into a ceramic or the like, the fibers serve as an aggregate for the ceramic, and increase the strength of the plasma protection member 5 against stress. As a result, resistance to stress caused by dimensional changes in the surroundings is increased, and the service life of the plasma-resistant structure 1 can be extended.

[0041]

As the fiber(s) forming the plasma protection member 5, inorganic fibers are preferred. Examples of the inorganic fibers include those including at least one of yttrium, aluminum, zirconium, hafnium, calcium, magnesium, nickel, titanium, and silicon. The plasma protection member 5 may also be formed from oxides, hydroxides, or carbides of these materials; fibers obtained by coating organic fibers with these inorganic compounds; or mixtures of these materials. However, the fiber(s) are not limited thereto. Furthermore, examples of inorganic fibers that are commercially available include Fineflex (Nichias Corporation), Isowool (Isolite Insulating Products Co., Ltd.), Ibiwool (Ibiden Co., Ltd.), Superwool (Shin-Nippon Thermal Ceramics Corporation), Nextel (3M Company), N-Silica (Japan Glass Fiber Industrial Co., Ltd.), BelCo Tex (BelChem), Nichibi Alph (Nichibi Co., Ltd.), Almax (Mitsui Mining & Smelting Co., Ltd.), SAFFIL (Saffi Fibres Ltd.), Denka Alcen (Denka Company Limited), Rubiru (Nichias Corporation), Maftec (Mitsubishi Chemical Advanced Materials Co., Ltd.), Altex (Sumitomo Chemical Co., Ltd.), Rockfiber (Nittobo Co., Ltd.), MG Mighty Wool (Nichias Corporation), S-fiber (Nippon Rockwool Co., Ltd.), Rockfil (Lapinus), Nicalon (Nippon Carbon Co., Ltd.), Tyranno Fiber (UBE Corporation), Naslon (Nippon Seisen Co., Ltd.), Bekipor (Bekaert), Bolfur (Unitika Ltd.), Sency (Unitika Ltd.), Unitika Glass Fiber (Unitika Ltd.), Nittobo Glass Fiber (Nittobo Co., Ltd.), E-glass (Nippon Electric Glass Co., Ltd.), ARG (Nippon Electric Glass Co., Ltd.), and Alfiber (Asahi Fiber Glass Co., Ltd.).

[0042]

The plasma protection member 5 is disposed on the outer surface side of the plasma-resistant structure 1 at an end portion of the intermediate member 4 not facing the first

member 2 and the second member 3. Here, the “end portion” refers to a surface of the intermediate member 4, the surface not facing the first member 2 and the second member 3 but facing the plasma protection member 5 or the plasma space. The plasma protection member 5 may be disposed on the outer periphery of the intermediate member 4 not facing the first member 2 and the second member 3. The plasma protection member 5 is preferably provided along the outer periphery of the intermediate member 4. Thus, the plasma protection member 5 covers portions of the intermediate member 4 which do not face the first member 2 and the second member 3 (e.g., the end portion, outer surface side, outer periphery, inner surface side, and inner periphery of the intermediate member 4), whereby the path from the plasma space to the intermediate member 4 is blocked. As such, the distance before the plasma reaches the intermediate member 4 increases, and the plasma becomes deactivated, thereby reducing adverse effects of plasma on the intermediate member 4. The direction in which the fiber(s) of the plasma protection member 5 extend is preferably along the outer periphery of the intermediate member 4.

[0043]

The length of the fiber(s) of the plasma protection member 5 in the direction in which the fiber(s) extend may be longer than the length of the outer periphery of the intermediate member 4, and the fiber(s) may be wound along the outer periphery of the intermediate member 4 or tightly wound therearound (including cases where the fiber(s) extend around the periphery of the intermediate member 4 by one or multiple turns). The plasma protection member 5 may be directly wound around the intermediate member 4, and is preferably wound therearound while applying pressure to the intermediate member 4. By winding under pressure, gaps (voids) provided between the fiber(s) of the plasma protection member 5 are reduced, thereby further isolating the intermediate member 4 from the plasma space. Furthermore, the plasma protection member 5 may be wound, while being interposed between (in contact with) the first member 2 and the second member 3 (in which case, the plasma protection member 5 may be spaced apart from the intermediate member 4). Interposing the plasma protection member 5 between the first member 2 and the second member 3 further reduces or eliminates the gaps (voids) provided between the fiber(s) of the plasma protection member 5, thereby further isolating the intermediate

member 4 from the plasma space. As a result, a plasma-resistant structure 1 with a long service life can be provided.

[0044]

In the present specification, the “fiber” refers to a thread-like material, and its structure (shape) is not particularly limited. The diameter of the fiber of the plasma protection member 5 is preferably 5 μm to 0.2 mm and more preferably 5 μm to 0.1 mm. The average diameter of fibers falling within these ranges is preferable from the viewpoints of stress relaxation properties and plasma resistance. The aspect ratio (length/diameter) of the fiber is preferably 1,000 to 2,200,000, more preferably 28,000 to 2,200,000, and further preferably 140,000 to 1,200,000, although it depends on the applications. This is because a larger fiber length (aspect ratio) tends to provide better plasma resistance, durability, and particle resistance.

[0045]

The structure (shape) of the plasma protection member 5 including fiber(s) is not particularly limited. The plasma protection member 5 may be a fiber structure including fiber(s). In the fiber structure, a plurality of fibers are entangled, twisted, braided, or bound together and can be used as an integral body, and the fiber structure has gaps (voids) between the fiber and fiber (or turns). Thus, stress relaxation properties against thermal stress or the like are ensured, thereby providing a plasma-resistant structure 1 with a long service life. Within a range that does not impair the plasma resistance of the fiber structure, the gaps may be filled with a binder such as a resin, or may be partially filled with the binder. Thus, the mechanical strength of the fiber structure is improved. As a result, a plasma-resistant structure 1 with a long service life can be provided. The shape of the fiber structure is not particularly limited, and examples of the shape include a thread-like shape, a rope-like shape, a layered shape, a belt-like shape, a sleeve-like shape, and annular forms of these shapes. The fiber structure may be, for example, a twisted yarn, a nonwoven fabric, a woven fabric, or a mesh-like structure, or may be composed of a plurality of components (fibers etc.) including gaps (voids). By using these fiber structures, stress relaxation properties against thermal stress or the like are ensured, thereby providing a plasma-resistant structure 1 with a long service life. As methods for manufacturing these fiber

structures, known methods appropriate to the intended use can be employed. For example, a twisted yarn can be manufactured by combining a plurality of fibers and applying a twist thereto, and a nonwoven fabric can be manufactured by a dry process or a wet process. However, methods are not limited thereto. The above “voids” of the plasma protection member 5 are not particularly limited as long as the stress relaxation properties and extended service life described above can be achieved. For example, the plasma protection member 5 may be a single fiber which is made of the above-described plasma-resistant material and which is wound along and around the outer periphery of the intermediate member 4. Even in this case, the voids between turns of the wound fiber can follow dimensional changes in the first member 2 and the second member 3, and exhibit an effect of relieving stress generated by such dimensional changes. As a result, a plasma-resistant structure 1 with a long service life can be provided.

[0046]

(Dimensions of fiber(s) in fiber structure)

The diameter of each fiber of the fiber structure is preferably 5 μm to 0.2 mm and more preferably 5 μm to 0.1 mm. The average diameter of the fiber(s) falling within these ranges is preferable from the viewpoints of stress relaxation properties and plasma resistance. The aspect ratio of each fiber of the fiber structure is preferably 500 or more, more preferably 1000 or more, and further preferably 8000 or more. When each fiber is such a long fiber, stress relaxation properties of the plasma protection member 5 are improved, thereby providing a plasma-resistant structure 1 with a long service life. The “diameter” of the fiber(s) in the present specification refers to the average value (e.g., the average for 20 fibers) of the equivalent-area diameters determined by: calculating the cross-sectional area at any cross-section perpendicular to the extending direction of the fiber(s) as captured with a microscope (e.g., the calculation is performed using known software); and then calculating the diameter of a circle having the same area as the calculated cross-sectional area. Furthermore, the “length” of fiber(s) in the present specification refers to, for example, the average length of any ten fibers in the fiber structure.

[0047]

The plasma protection member 5 (fiber structure) preferably includes a fiber bundle.

Specifically, the use of a fiber bundle, rather than merely including fibers, improves stress relaxation properties, strength, and handling properties (including placement and removal). The materials, dimensions, and the like of the individual fibers in the fiber bundle may be the same or different from each other. Preferably, the fibers are aligned in direction and orientation and have substantially the same dimensions. The number of fibers bundled is not particularly limited, and can be appropriately set in consideration of the thickness of the intermediate member 4, the diameter of each fiber, and the like. For example, a fiber bundle composed of inorganic fibers is preferably interposed between (in contact with) the first member 2 and the second member 3. That is, when the fiber bundle is interposed between the first member 2 and the second member 3, the gaps (voids) provided between the fibers in the fiber bundle are compressed and reduced, whereby the intermediate member 4 is isolated from the plasma atmosphere and the fiber bundle can be made less likely to come off. By selecting and setting the number of fibers in this manner, the service life of the plasma-resistant structure 1 can be extended. Furthermore, in the fiber bundle, the fibers are preferably bound to each other to an extent that both shape retention and cushioning properties can be achieved. By using such a fiber structure, a plasma-resistant structure 1 with a long service life can be provided.

[0048]

The extending (longitudinal) direction of the fiber structure is preferably along the outer periphery of the intermediate member 4, too. In other words, the fiber bundle forming the plasma protection member 5 also preferably extends along the outer periphery of the intermediate member 4. In this case, the fiber structure can be inserted along the direction in which the gap between the first member 2 and the second member 3 extends. Thus, the path from the plasma space to the intermediate member 4 is blocked, and the distance before the plasma reaches the intermediate member 4 increases. As such, the plasma becomes deactivated, thereby reducing adverse effects of plasma on the intermediate member 4. The direction of the individual fibers in the fiber bundle is preferably along the outer periphery of the intermediate member 4, too. When the fibers are aligned in the same direction, the fiber bundle serving as the plasma protection member 5 can be uniformly inserted between the first member 2 and the second member 3. Therefore, the

gaps between the first member 2 and the plasma protection member 5 and between the second member 3 and the plasma protection member 5 are reduced, thereby improving plasma resistance. As a result, the service life of the plasma-resistant structure 1 can be extended.

[0049]

The length of the fiber structure of the plasma protection member 5 in the extending direction thereof may be longer than the length of the outer periphery of the intermediate member 4, and the fiber structure may be wound around the outer periphery of the intermediate member 4 (FIG. 3). FIG. 3(A) and (B) represent examples of a top view and a perspective view of the plasma-resistant structure 1 when the plasma protection member 5 is wound around the outer periphery of the intermediate member 4.

[0050]

The fiber bundle included in the plasma protection member 5 preferably has a twisted shape. The twisted fibers can move relative to each other within the fiber bundle, so that both high strength and cushioning properties can be achieved. In addition, the high strength of the twisted fibers can increase the strength of the plasma protection member 5, and facilitates removal of the plasma protection member 5 from the plasma-resistant structure 1. Furthermore, stress relaxation can also be achieved when the twisted fibers loosen in the fiber bundle. Although the twisting manner is not particularly limited, the number of twists can be 5 to 360 per meter, preferably in a range of 20 to 300 per meter. When the number of twists is within the above range, it is possible to achieve, in a well-balanced manner, strength and stress relaxation properties of the fiber bundle, and suppression of particle generation during plasma processing. As a result, a plasma-resistant structure 1 with a long service life can be provided. Here, the “particle(s)” refer primarily to small fragments generated from the plasma-resistant structure 1 during plasma processing. Such particles may become contaminants on a workpiece W being held. For example, if the strength of the plasma protection member 5 is low, the fibers may be broken by plasma processing and adhere as particles to the workpiece W. Furthermore, if the plasma protection member 5 does not sufficiently isolate or distance the intermediate member 4 from the plasma atmosphere, the intermediate member may be degraded and broken under the plasma

atmosphere, and may adhere as particles to the workpiece W.

[0051]

The diameter of each fiber of the fiber bundle is preferably 5 μm to 0.2 mm, more preferably 5 μm to 0.1 mm, and further preferably 5 μm to 20 μm. The average diameter of the fibers falling within these ranges is preferable from the viewpoints of stress relaxation properties and plasma resistance. The aspect ratio of each fiber of the fiber bundle is preferably 500 or more, more preferably 1000 or more, and further preferably 8000 or more. When each fiber is such a long fiber, stress relaxation properties of the plasma protection member 5 are improved, thereby providing a plasma-resistant structure 1 with a long service life. The "diameter" of the fiber(s) in the present specification refers to the average value (e.g., the average for 20 fibers or fiber bundle) of the equivalent-area diameters determined by: calculating the cross-sectional area at any cross-section perpendicular to the extending direction of the fiber(s) or the fiber bundle as captured with a microscope (e.g., calculation is performed using known software); and then calculating the diameter of a circle having the same area as the calculated cross-sectional area. Furthermore, the "length" of a fiber bundle in the present specification refers to, for example, the average length of any ten fibers in the fiber bundle.

[0052]

The plasma protection member 5 may not necessarily be bound to the first member 2, the second member 3, or the intermediate member 4. For example, a fiber structure (such as a twisted yarn, a mesh, a nonwoven fabric, or a metal wire) as the plasma protection member 5 may be pushed in from between the first member 2 and the second member 3 toward the intermediate member 4.

[0053]

When the fiber structure as the plasma protection member 5 is pushed in from between the first member 2 and the second member 3 toward the intermediate member 4, the fiber structure may be installed while being compressed by the first member 2 and the second member 3 (case 1), or may be installed while being compressed from the outer surface side of the intermediate member 4 toward the intermediate member 4 (case 2).

[0054]

As an embodiment (case 1) in which the fiber structure is installed while being compressed by the first member 2 and the second member 3, there is a case where a diameter (hereinafter denoted as “D”) of the plasma protection member 5 (fiber structure, fiber bundle) in a state not installed between the first member 2 and the second member 3 (pre-installation state or a non-installed state) is larger than a length between the first member 2 and the second member 3 (i.e., the thickness of the intermediate member 4; hereinafter denoted as “H” for explanation). In the present disclosure, the plasma protection member 5 is preferably capable of installation within the length between the first member 2 and the second member 3 that is the length H smaller than the diameter D of the plasma protection member 5 (D>H). In this case, when the fiber structure is installed between the first member 2 and the second member 3, the gaps (voids) provided between the fibers (or turns) in the fiber structure are reduced, and the intermediate member 4 is isolated or distanced from the plasma atmosphere, thereby achieving both stress relaxation properties and plasma resistance. As a result, a plasma-resistant structure 1 with a long service life can be provided. The diameter D of the fiber structure can be defined as the diameter of a minimum circumscribed circle of the fiber structure in a cross-sectional view perpendicular to the direction in which the fiber structure extends but in the non-installed state between the first member 2 and the second member 3. In FIG. 8, each circle illustrates an example of the minimum circumscribed circle of a fiber bundle (fiber structure). In the example shown in FIG. 8, the diameters D of the fiber structures are 269 μm and 244 μm. In this non-installed state, the space factor of the fiber structure (area occupied by the fiber(s) within the minimum circumscribed circle / area of the minimum circumscribed circle) is 63%. The space factor of the fiber structure is preferably 20% to 80%, and more preferably 30% to 70%. The space factor within these ranges facilitates the installation between the first member 2 and the second member 3, and gaps (voids) provided between the fiber(s) in the fiber structure in the installed state are reduced, whereby the intermediate member 4 is isolated or distanced from the plasma atmosphere. As a result, a plasma-resistant structure 1 with a long service life can be provided. In the present disclosure, the space factor of the fiber structure is defined as an average value of space factors, for example, an average value of 20 cross-sectional images captured, using a microscope, at any cross

sections perpendicular to the direction in which the fiber structure extends. Specifically, each space factor is calculated (e.g., using known software) from: the area occupied by the fibers within the minimum circumscribed circle; and the area of the minimum circumscribed circle.

[0055]

FIG. 9 shows a cross-sectional image of an electrostatic chuck (plasma-resistant structure 1) as a specific example of case 1. A fiber bundle (fiber structure) is wound around the outer periphery of the intermediate member 4 disposed between the first member 2 and the second member 3. In this example, the length H between the first member 2 and the second member 3 (the thickness of the intermediate member 4) is 100 μm, and the diameter of the fiber is 7 μm. The diameter D of one (on the right side) of the fiber structures in the non-installed state is 150 μm and the space factor thereof is 53%. The fiber structure is wound 4 times around the outer periphery of the intermediate member 4. That is, the fiber structure is disposed between the first member 2 and the second member 3 having the length H therebetween smaller than the diameter D of the fiber structure. Thus, the gaps provided between the fibers in the fiber structure are reduced, and the intermediate member 4 is isolated or distanced from the plasma atmosphere, thereby achieving both cushioning properties and followability. As a result, a plasma-resistant structure 1 with a long service life can be provided.

[0056]

In the present disclosure, (diameter D of fiber structure) / (length H between first member 2 and second member 3) is preferably 1 or more, more preferably 1.2 or more, and further preferably 1.5 or more. In other words, the fiber structure is deformable such that the diameter D is decreased to preferably 83% of the value, more preferably 67% of the value, when the fiber structure is compressed perpendicularly to its center (center of gravity). Thus, favorable cushioning properties and followability can be exhibited. In addition, in such a plasma-resistant structure 1, the gaps provided between the fibers in the fiber structure are reduced, and the intermediate member 4 can be isolated or distanced from the plasma atmosphere. As a result, a plasma-resistant structure 1 with a long service life can be provided. The D/H in FIG. 9 is 1.5.

[0057]

As an embodiment (case 2) in which the fiber structure is installed while being compressed from the outer surface side of the intermediate member 4 toward the intermediate member 4, there is a case where a plurality of fiber structures are overlapped and pushed in along the outer periphery of the intermediate member 4. FIG. 10 shows a cross-sectional image of an electrostatic chuck (plasma-resistant structure 1) as a specific example of this embodiment. A fiber bundle (fiber structure) is wound around the outer periphery of the intermediate member 4 disposed between the first member 2 and the second member 3. In this example, the length H between the first member 2 and the second member 3 (the thickness of the intermediate member 4) is 565 μm, and the diameter of the fiber is 7 μm. The diameter D of the fiber structure in the non-installed state is 150 μm and the space factor thereof is 46%. The fiber structure is wound 32 times along the outer periphery of the intermediate member 4. That is, the fiber structure is disposed between the first member 2 and the second member 3 having the length H therebetween larger than the diameter D of the fiber structure. However, compared to FIG. 9, many fiber structures are overlapped from the outer surface side of the intermediate member 4 toward the intermediate member 4. Thus, the gaps provided between the fibers in the fiber structure are reduced, and the intermediate member 4 is isolated or distanced from the plasma atmosphere. As a result, a plasma-resistant structure 1 with a long service life can be provided.

[0058]

Furthermore, in a cross-sectional view perpendicular to the extending direction of the fiber structure installed in the plasma-resistant structure 1, at least a portion of the intermediate member 4 is preferably isolated or distanced from the plasma atmosphere by a region in which fibers are densely present. As a result, a plasma-resistant structure 1 with a long service life can be provided. Specifically, the fiber structure installed between the first member 2 and the second member 3 preferably has a space factor not smaller than 50% and not greater than 95% in a certain region (referred to as “region A” in FIG. 10) defined by (length H between first member 2 and second member 3) × (length of 20 μm in direction perpendicular to length H). The space factor is more preferably not smaller than 60% and

not greater than 95%, and further preferably not smaller than 70% and not greater than 90%. Accordingly, the intermediate member 4 can be isolated or distanced from the plasma atmosphere while ensuring stress relaxation properties of the fiber structure. As a result, a plasma-resistant structure 1 with a long service life can be provided. The fiber structure preferably has a space factor not smaller than 50% and not greater than 95% in a certain region (referred to as “region B”) defined by (length H between first member 2 and second member 3) × (length of 80 μm in direction perpendicular to length H). The space factor is more preferably not smaller than 60% and not greater than 95%, and further preferably not smaller than 70% and not greater than 90%. The fiber structure preferably has a space factor not smaller than 50% and not greater than 95% in a certain region (referred to as “region C”) defined by (length H between first member 2 and second member 3) × (length of 160 μm in direction perpendicular to length H). The space factor is more preferably not smaller than 60% and not greater than 95%, and further preferably not smaller than 70% and not greater than 90%. Accordingly, by more widely providing a region in which fibers are densely present so as to isolate or distance the intermediate member 4 from the plasma atmosphere while ensuring stress relaxation properties of the fiber structure, the intermediate member 4 is more isolated from the plasma atmosphere. As a result, a plasma-resistant structure 1 with a long service life can be provided.

[0059]

FIG. 10 shows this specific example. FIG. 10 is a cross-sectional image showing an example in which a fiber bundle (fiber structure) is compressed and installed from the outer surface side of the intermediate member 4 toward the intermediate member 4. In this case, the space factor of the fiber structure in region A is 82%. Accordingly, the intermediate member 4 can be isolated or distanced from the plasma atmosphere while ensuring stress relaxation properties of the fiber structure. As a result, a plasma-resistant structure 1 with a long service life can be provided. In the case of FIG. 9 as well, the space factor of the fiber structure in region A0 was 76% (the space factor of the fiber structure before installation was 53%). In the example of FIG. 9 (case 1), the fiber structure on the intermediate member 4 side is dense, while that on the outer surface side is sparse. That is, the space factor of the fiber structure on the intermediate member 4 side is greater than

the space factor of the fiber structure on the outer surface side. This is mainly because the fiber structure closer to the intermediate member 4 side is more compressed. In this case as well, the intermediate member can be distanced from the plasma atmosphere, and as a result, a plasma-resistant structure 1 with a long service life can be provided.

[0060]

FIG. 11 shows still another specific example. In this case, the length H between the first member 2 and the second member 3 (the thickness of the intermediate member 4) is 70 μm, the diameter of the fiber in the fiber structure is 7 μm, and the number of turns (number of times the fiber structure is wound) is 16. The diameter D of the fiber structure in the non-installed state was 150 μm and the space factor thereof was 51%. The space factor of the fiber structure in region A was 83%. That is, in this case as well, the intermediate member 4 can be isolated or distanced from the plasma atmosphere while ensuring stress relaxation properties of the fiber structure. As a result, a plasma-resistant structure 1 with a long service life can be provided.

[0061]

The shape of the fiber structure in a stacked state between the first member 2 and the second member 3 and the shape of the wound fiber bundle are not particularly limited, and may be spherical, elliptical, crescent-shaped, rectangular, or the like.

[0062]

The outermost surface of the plasma protection member 5 (fiber structure) installed on the outer surface side of the intermediate member 4 is preferably fixed. Thus, fraying and damage of the fiber structure are reduced, and a state in which the gaps (voids) provided between the fiber(s) in the fiber structure are compressed can be maintained. As a result, a plasma-resistant structure with a long service life can be provided. The fixing means is not particularly limited. Examples of the fixing means include fixing by inter-fiber interactions (tying, entangling, hooking, etc.), fixing using a resin, and fixing using an inorganic material. As a specific example of fixing using a resin, a reactive silicone resin (e.g., KE-103 manufactured by Shin-Etsu Chemical Co., Ltd.) may be applied to the outermost surface of the fiber structure and be left standing to cure at room temperature, thereby fixing the fiber structure. Alternatively, the outermost surface of the fiber structure

may be coated with a resin and fixed. For example, the fiber structure may be inserted into a heat-shrink tube (e.g., PTFE tube, SLW-AWG34HS, manufactured by Hagitec Co., Ltd.), and the tube may be heat-shrunk to fix the fiber structure. As a specific example of fixing using an inorganic material, an inorganic material melted by heating (e.g., a solder material, glass, etc.) or a solution including an inorganic material (an organometallic compound, etc.) may be applied to the outermost surface of the fiber structure, followed by cooling and solidification or drying and solidification, respectively, thereby fixing the fiber structure. In this manner, particles generated from the fiber structure can also be reduced.

[0063]

The plasma protection member 5 and the intermediate member 4 are preferably spaced apart at least in part, and more preferably are spaced apart in a part and in contact with each other in another part. (For example, in an electrostatic chuck 21 having the plasma-resistant structure shown in FIG. 5, the side of a plasma protective material 25 being in contact with a first member 22 and the side thereof being in contact with a second member 23 are spaced apart from an outer peripheral portion 24a of a bonding layer 24 serving as an intermediate member.) If the plasma protection member 5 is completely spaced apart from the intermediate member 4, there is a risk that the plasma protection member 5 may come off. However, when they are spaced apart from each other in a part and are in contact with each other in another part, stress relaxation properties can be improved. As a result, a plasma-resistant structure 1 with a long service life can be provided.

[0064]

Hereinafter, other embodiments of the present disclosure will be described, in which reference characters of the components the same as or similar to those of the plasma-resistant structure 1 are denoted by adding 10, 20, 30, 40 and so on (that is, for example, a plasma protection member 15 in FIG. 4 is a component the same as or similar to the plasma protection member 5). In addition, as particularly preferable embodiments, the same as or similar components may be assigned different names (for example, an edge ring portion 42 and an edge ring portion 43 shown in FIG. 6 correspond to the first member 2 and the second member 3, respectively, and may be formed from a plasma-resistant material, but are given different names). Descriptions of such components are omitted as

appropriate.

[0065]

[Electrostatic chuck 11]

According to the present disclosure, an electrostatic chuck 11 including a plasma-resistant structure 1 as shown in FIG. 4 is provided. That is, in FIG. 4, the plasma-resistant structure 1 may include a holding member 12 that holds a workpiece W, and a base 13 that supports the holding member 12. More specifically, the electrostatic chuck 11 includes the holding member 12 that holds the workpiece W, the base 13 that supports the holding member 12, a bonding layer 14 disposed between the holding member 12 and the base 13, and a plasma protection member 15 including fiber(s). The plasma protection member 15 including the fiber(s) is disposed on the outer surface side of the electrostatic chuck 11 at an end portion of the bonding layer 14. The plasma protection member 15 has resistance to plasma as described later, and the plasma protection member 15 can be provided not only at the bonding layer 14 but also at a desired position of the electrostatic chuck 11 (e.g., a heat insulating layer, a heat transfer layer, a conductive layer, an insulating layer, an O-ring, etc.).

[0066]

(Holding member 12)

The holding member 12 adsorbs and holds the workpiece W. The shape of the holding member 12 is not limited, and may be a disk shape or a quadrangular shape in accordance with the shape of the workpiece W. The dimensions of the holding member 12 can also be set as appropriate in accordance with the workpiece W. The “workpiece W” is also not limited, and may include, for example, a wafer (silicon wafer, quartz wafer, SiC wafer, etc.), a flat panel display (FPD) panel, a substrate, a metal member, a film member, a resin member (automotive interior component, etc.), a glass member, etc.

[0067]

Examples of the holding member 12 include a ceramic substrate (alumina, aluminum nitride, yttrium oxide, zirconium oxide, silicon carbide, etc.), a resin substrate, and a metal substrate made of aluminum, stainless steel, etc. Examples of the resin substrate include polyimide, polyamide, polyamide-imide, aromatic polyether ketone, fluoropolymer, etc., from the

viewpoints of plasma resistance and heat resistance. The holding member 12 may be a substrate composed of two or more types of materials. From the viewpoints of plasma resistance and heat resistance, the holding member 12 is preferably a ceramic substrate, a resin substrate, or a composite substrate composed of a ceramic and a resin.

[0068]

The thickness of the holding member 12 is also not particularly limited, and may be within a range from 0.2 mm to 7 mm. If an internal electrode is provided in the holding member 12 as described later, the thickness of the holding member 12 may be within a range from 3 mm to 10 mm.

[0069]

A plurality of protrusions may be provided on a surface of the holding member 12 on the side that holds the workpiece W. By holding (adsorbing) the workpiece W on the upper surfaces of these protrusions, the contact area between the holding member 12 and the workpiece W is reduced. As a result, the quality of the workpiece W can be maintained, and the service life of the electrostatic chuck 11 can be extended. The number, arrangement, shape, height, dimensions, and the like of the protrusions are not particularly limited. From the viewpoints of maintaining the quality of the workpiece W, the protrusions preferably have a disk-like shape or a columnar shape, and the upper surface of each protrusion is preferably flat. Setting the shape, height, and the like of the protrusions as described above stabilizes holding (adsoption) of the workpiece W and can favorably maintain the quality of the workpiece W, and an electrostatic chuck 11 with a longer service life can be provided.

[0070]

(Base 13)

The base 13 supports the holding member 12, and also has a cooling function. Designing for the shape, material, thickness, and the like of the base 13 can be changed as appropriate in accordance with the application. For example, the material of the base 13 may be a ceramic, a metal, or a combination thereof. Examples of the ceramic include alumina, aluminum nitride, yttrium oxide, and silicon carbide, and examples of the metal include aluminum and stainless steel. However, the present disclosure is not limited thereto.

[0071]

(Bonding layer 14)

The bonding layer 14 bonds the members such as the holding member 12 and the base 13. The thickness (height) of the bonding layer 14 is not particularly limited, and is preferably 20 μm to 1000 μm, more preferably 50 μm to 800 μm, and further preferably 100 μm to 500 μm. When the thickness of the bonding layer 14 is within these ranges, the bonding layer 14 can suitably withstand stress due to dimensional changes of the holding member 12 and the base 13 during heating, and can restrict contact between the bonding layer 14 and the plasma atmosphere in a plasma processing step. As a result, an electrostatic chuck 11 with a longer service life can be provided.

[0072]

The material of the bonding layer 14 may be a metal, an adhesive material (resin), or the like. As the metal, from the viewpoint of workability, a brazing filler metal (silver, copper, copper-alloy, aluminum, nickel, active silver, titanium, a solder, etc.) can be used. However, the material is not limited thereto. A more appropriate brazing filler metal can be selected in view of the properties (thermal expansion, thermal conductivity, etc.) of the holding member 12 and the base 13 to be bonded. Examples of the adhesive material include thermoplastic elastomer, thermosetting elastomer, epoxy resin, urethane resin, polyester resin, polyimide resin, polyamide resin, fluororesin, acrylic resin, silicone resin, urethane resin, and these materials mixed with fillers. From the viewpoints of adhesion and heat resistance, silicone resin, acrylic resin, epoxy resin, and these materials mixed with fillers are preferable, and silicone resin and silicone resin mixed with filler are more preferable.

[0073]

The bonding layer 14 may include a thermally conductive filler. By including the thermally conductive filler, both adhesion and thermal conductivity can be achieved, thereby suppressing thermal degradation of the bonding layer 14. As a result, an electrostatic chuck 11 with a long service life can be provided. Examples of the thermally conductive filler include metal, alumina, aluminum nitride, silicon carbide, boron nitride, carbon black, carbon nanotube, and diamond. However, the thermally conductive filler is not particularly

limited thereto. The amount, shape, and the like of the thermally conductive filler are also not particularly limited.

[0074]

According to the present disclosure, an electrostatic chuck 21 as shown in FIG. 5 can also be provided. The bonding layer 24 may vary depending on the position in the planar direction, and different bonding layers 24 may be used. For example, different types of materials may be used for a center portion 24b and an outer peripheral portion 24a of the bonding layer 24 (FIG. 5). This configuration allows the bonding layer 24 to suitably withstand stress due to dimensional changes of the holding member 22 and the base 23 during heating.

[0075]

(Plasma protection member 15)

The plasma protection member 15 isolates or distances the bonding layer 14 from the plasma atmosphere to protect the bonding layer 14, and is preferably disposed along the outer periphery of the bonding layer 14.

[0076]

The plasma protection member 15 may be a combination of different materials. The plasma protection member 15 may also be a fiber structure such as a twisted yarn as described above.

[0077]

(Protection material)

The electrostatic chuck 11 may further include a protection material (not shown) provided along the outer periphery of the plasma protection member 15. This protection material can increase the strength of the plasma protection member 15 and reduce particles generated from the plasma protection member 15. Furthermore, the protection material can fix and retain the plasma protection member 15. For example, when the plasma protection member 15 is wound around the outer periphery of the bonding layer 14, a tip end portion of the plasma protection member 15 may be provided with the protection material for fixation. The protection material may have elasticity that allows expansion and contraction. As a result, when the plasma protection member 15 is attached and fixed to

the bonding layer 14 by the protection material without winding the plasma protection member 15 around the outer periphery of the bonding layer 14, the plasma protection member 15 can be detached without unwinding the plasma protection member 15 from the electrostatic chuck 11. In addition, from the viewpoint of stress relaxation, at least a part of the protection material is preferably spaced apart from the plasma protection member 15.

[0078]

As the protection material, an organic material such as a resin can be used to fix and retain the plasma protection member 15. Examples of the resin include silicone resin, fluororesin, epoxy resin, polyimide resin, and acrylic resin. Furthermore, in order to protect the bonding layer 14 and the plasma protection member 15, a plasma-resistant material may be used, and it is particularly preferable to use alumina, silicon carbide, metal oxide, or the like.

[0079]

The protection material can be formed by applying and then sintering a paste including inorganic particles, a solution of a metallic organic compound, or a metal complex solution, or can also be formed by thermal-spraying an inorganic material.

[0080]

(Other matters)

According to the present embodiments, the electrostatic chuck 11 may include an internal electrode (not shown) in the holding member 12 in order to apply voltage to generate an electrostatic force (Coulomb force) and adsorb the workpiece W. Alternatively, such an internal electrode may be provided in the base 13.

[0081]

The internal electrode is not particularly limited as long as it is formed from an electrically conductive material that can generate an electrostatic adsorption force when voltage is applied. As the internal electrode, for example, a thin film made of a metal such as copper, aluminum, gold, silver, platinum, chrome, nickel, or tungsten, or a thin film made of at least two kinds of metals selected from the above metals, is favorably used. A ceramic material including such an electrically conductive material may also be used. Such a thin film of an electrically conductive material may be formed by vapor deposition, plating, sputtering,

thermal-spraying, or the like, or may be formed by applying and drying an electrically conductive paste. Specifically, a metal foil such as copper foil, aluminum foil, nickel foil, or stainless steel foil may be used.

[0082]

Preferably, the outermost periphery of the holding member 12 is located outward of an outermost portion of the plasma protection member 15 (or the protection material). More preferably, the outermost periphery of the base 13 is also located outward of the outermost portion of the plasma protection member 15 (or the protection material) (FIG. 4). This is because degradation of the plasma protection member 15 or the protection material due to plasma can be suppressed. Furthermore, the outermost periphery of the holding member 12 is preferably located outward of the outermost periphery of the base 13 because this configuration prevents interference between the base 13 and other members such as the edge ring 41 (FIGS. 6, 7) used together with the electrostatic chuck 11.

[0083]

(Manufacturing method for and usage of electrostatic chuck 11)

The electrostatic chuck 11 can be manufactured as follows, for example. First, a holding member 12 and a base 13 are prepared. At this point, as described above, an internal electrode is formed on either the holding member 12 or the base 13 by patterning a metal such as copper. Next, the holding member 12 and the base 13 are joined via the bonding layer 14. These steps are also carried out in conventional methods for manufacturing electrostatic chucks. In conventional electrostatic chucks, after the holding member and the base are joined via the bonding layer, an O-ring or an adhesive (elastomer, acrylic rubber, silicone rubber, fluororubber, thermosetting resin, etc.) is provided. In contrast, in embodiments of the present disclosure, a plasma protective material 15 as described above is provided on the outer surface side of the electrostatic chuck 11 at the end portion of the bonding layer 14. Furthermore, the protective material is appropriately provided along the outer periphery of the plasma protective material 15 (FIG. 4).

[0084]

In the electrostatic chuck 11 according to the present embodiments, voltage is applied to the internal electrode buried in the holding member 12 or the base 13, thereby generating

a Coulomb force and adsorbing the workpiece W. For example, in dry etching or a CVD process in a semiconductor manufacturing process, the electrostatic chuck 11 can be used for adsorbing a wafer (workpiece W). In particular, in an apparatus or a method that uses plasma, with the electrostatic chuck 11 according to the present embodiments, even if the holding member 12 and the base 13 expand at a high temperature (e.g., 250°C) due to plasma irradiation, in the case where, for example, the plasma protection member 5 includes an inorganic fiber structure, voids generated between inorganic fibers can absorb stress caused by a difference in thermal expansion and contraction between the holding member 12 and the base 13. As a result, the service life of the electrostatic chuck 11 can be extended. Furthermore, in the case where the plasma protection member 15 is formed by mixing fibers as described above into a ceramic or the like, the fibers serve as an aggregate for the ceramic, and increase the strength of the plasma protection member 15 against stress. As a result, resistance to stress caused by dimensional changes in the surroundings is increased, and the service life of the electrostatic chuck 11 can be extended.

[0085]

Furthermore, compared to the conventional electrostatic chucks, the method for manufacturing the electrostatic chuck 11 differs mainly in whether the plasma protection member 15 is provided. Therefore, when repairing a conventional electrostatic chuck, an electrostatic chuck 11 according to the present disclosure can be easily manufactured therefrom (FIG. 3).

[0086]

According to the present disclosure, an electrostatic chuck 31 as shown in FIG. 12(a) can also be provided. The electrostatic chuck 31 may have one or more through-holes 36 that penetrate from a base 33 to an upper surface 32a of a holding member 32. The function of the through-hole 36 is not particularly limited. The through-hole 36 may serve as a flow path for a heat transfer gas for temperature control of a workpiece W and the holding member 32, or may serve as a hole for accommodating a lift pin P for raising the workpiece W (FIG. 12(b)). In these cases, an inner wall 36a of the through-hole 36 (the electrostatic chuck 31, the holding member 32, a through-recess 33a of the base 33, and an inner surface 34b of a bonding layer 34) may be exposed to the plasma atmosphere. In such a

case, a plasma protection member 35 may be provided on the inner surface 34b side of the bonding layer 34 in the through-hole 36 (which is also the outer surface side of the electrostatic chuck 31). The plasma protection member 35 is preferably provided along the inner surface 34b of the bonding layer 34, and may be provided so as to extend along the inner surface 34b of the bonding layer 34. Thus, the path from the plasma space to the inner surface 34b of the bonding layer 34 is blocked, and the distance before the plasma reaches the inner surface 34b of the bonding layer 34 increases. As such, the plasma becomes deactivated, thereby reducing adverse effects of plasma on the bonding layer 34. As a result, an electrostatic chuck 31 with a long service life can be provided. For example, when a cylindrical through-hole 36 extending from the base 33 toward the holding member 32 is provided, the plasma protection member 35 is preferably installed along the inner surface 34b of the bonding layer 34. When the through-hole 36 serves as a flow path for a heat transfer gas for temperature control of the workpiece W and the holding member 32, the shape of the plasma protection member 35 is not limited as long as this function is not impeded. The plasma protection member 35 may be an annular shape or an arc shape, and may be installed such that the heat transfer gas passes through the space in the plasma protection member 35. Furthermore, when the through-hole 36 serves as a hole for accommodating the lifting pin P that raises the workpiece W, the shape of the plasma protection member 35 is not limited as long as this function is not impeded, and preferably installed in an annular shape, an arc shape, or the like. As for the method of installing the plasma protection member 35, it can be installed by the following procedure. First, the plasma protection member 35 is inserted through the through-recess 33a provided in the base 33. Then, an insulating member M that does not obstruct gas flow is inserted into the through-recess 33a, and the plasma protection member 35 is pushed upward and fixed on the inner surface 34b side of the bonding layer 34. In this event, the insulating member M and the plasma protection member 35 may be inserted simultaneously. This method provides a simple manufacturing method and structure without impairing the functions of the electrostatic chuck 31. As a result, an electrostatic chuck 31 with a longer service life can be manufactured.

[0087]

As long as gas permeation or vertical movement of the pin P is not obstructed, the shape of the insulating member M is not particularly limited and is preferably a cylindrical shape, a sleeve shape, a helical shape, a porous form, or the like along the through-hole 36. Thus, both the durability of the insulating member M and the functions of the electrostatic chuck 31 can be achieved. As a result, an electrostatic chuck 31 with a long service life can be provided. From the viewpoint of insulation, examples of preferable materials for the insulating member M include ceramic materials and resin materials. Examples of ceramic materials include oxides, hydroxide, and carbides including at least one of yttrium, aluminum, zirconium, hafnium, calcium, magnesium, nickel, titanium, and silicon. Specifically, yttrium oxide, aluminum oxide, and aluminum nitride are preferred. This improves the durability of the insulating member M. As a result, an electrostatic chuck 31 with a long service life can be provided. Examples of resin materials include polyimide, polyamide, polyamide-imide, aromatic polyether ketone, and fluoropolymer. From the viewpoint of plasma resistance, fluoropolymer is preferred. From the viewpoint of insulation, polyimide is preferred. These materials improve the durability of the insulating member M. As a result, an electrostatic chuck 31 with a long service life can be provided.

[0088]

[Edge ring 41]

Furthermore, as one embodiment of the present disclosure, an edge ring 41 having any plasma-resistant structure as shown in FIG. 6(A) and 6(B) is provided. FIG. 6(A) and FIG.6(B) are a perspective view and a cross-sectional view of the edge ring 41, respectively. The edge ring 41 of the present disclosure is formed so as to surround an outer periphery of an electrostatic chuck, and is preferably formed in a ring shape (annular shape) or an arc shape. The edge ring 41 is used in a plasma processing step to uniformly perform plasma processing on the workpiece W such as a wafer adsorbed to the upper surface of a holding member of the electrostatic chuck (FIG. 7). In FIG. 6, more specifically, the edge ring 41 has an edge ring portion 42, an edge ring portion 43, a bonding layer (intermediate member) 44 disposed between the edge ring portion 42 and the edge ring portion 43, and a plasma protection member 45 including fiber(s). The plasma protection member 45 is disposed on the outer surface side of the edge ring 41 at the bonding layer 44. The plasma

protection member 45 has resistance to plasma, and may be disposed not only at the bonding layer 44 but also at a desired position on the edge ring 41.

[0089]

(Edge ring portions 42, 43)

The edge ring portions 42, 43 constitute the edge ring 41. Examples of materials for the edge ring portions 42, 43 include, but are not limited to, a semiconductor, a conductor, an insulator, and a combination of at least two of these materials. By selecting a desired combination of these materials, dielectric properties can be controlled, whereby plasma processing can be uniformly performed on the workpiece W such as a wafer adsorbed to the upper surface of the holding member of the electrostatic chuck. As a result, an edge ring 41 with a long service life can be provided. The shapes of the edge ring portions 42, 43 and the bonding layer 44 are also not particularly limited, and are preferably a ring shape or an arc shape. Thus, the bonding layer 44 can be more effectively protected from the plasma atmosphere, and as a result, an edge ring 41 with a long service life can be provided.

[0090]

(Bonding layer 44)

The bonding layer 44 joins the members such as the edge ring portion 42 and the edge ring portion 43. The thickness (height) of the bonding layer 14 is not particularly limited, and is preferably 20 μm to 1000 μm, more preferably 50 μm to 800 μm, and further preferably 100 μm to 500 μm. When the thickness of the bonding layer 14 is within these ranges, the bonding layer 44 can suitably withstand stress due to dimensional changes of the edge ring portion 42 and the edge ring portion 43 during heating, and can restrict contact between the bonding layer 44 and the plasma atmosphere in the plasma processing step. As a result, an edge ring 41 with a longer service life can be provided.

[0091]

The bonding layer 44 and the plasma protection member 45 may be the same as the above-described bonding layer 14 and plasma protection member 15, respectively. The edge ring 41 may also be provided with a protection material.

[0092]

(Manufacturing method for and usage of edge ring 41)

The edge ring 41 can be manufactured as follows, for example. First, an edge ring portion 42 and an edge ring portion 43 are prepared. At this point, as described above, the edge ring portion 42 and the edge ring portion 43 are joined via the bonding layer 44. These steps are also carried out in conventional methods for manufacturing edge rings. In conventional edge rings, after the edge ring portion 42 and the edge ring portion 43 are joined via a bonding layer, an O-ring or an adhesive (elastomer, acrylic rubber, silicone rubber, fluororubber, thermosetting resin, etc.) is provided. In contrast, in embodiments of the present disclosure, a plasma protection member 45 as described above is provided on the outer surface side of the edge ring 41 at the end portion of the bonding layer 44. Furthermore, the protection material is appropriately provided along the outer periphery of the plasma protection member 45 (not shown).

[0093]

The edge ring 41 of the present embodiments has a long service life as described above. Furthermore, in an apparatus or a method that uses plasma, even if the edge ring portion 42 and the edge ring portion 43 expand at a high temperature due to plasma irradiation, in the case where, for example, the plasma protection member 45 includes an inorganic fiber structure, voids generated between inorganic fibers can absorb stress caused by a difference in thermal expansion and contraction between the edge ring portion 42 and the edge ring portion 43. As a result, the service life of the edge ring 41 can be extended. Furthermore, in the case where the plasma protection member 45 is formed by mixing fibers as described above into a ceramic or the like, the fibers serve as an aggregate for the ceramic, and increase the strength of the plasma protection member 45 against stress. As a result, resistance to stress caused by dimensional changes in the surroundings is increased, and the service life of the edge ring 41 can be extended.

[0094]

Moreover, compared to the conventional edge rings, the method for manufacturing the edge ring 41 differs mainly in whether the plasma protection member 45 is provided. Therefore, when repairing a conventional electrostatic chuck, the edge ring 41 of the present disclosure can be easily manufactured.

[0095]

[Component for plasma processing apparatus]

Components for a plasma processing apparatus each including a plasma-resistant structure can be provided as an embodiment of the present disclosure, although not shown in the drawings. In a plasma processing apparatus, a chamber and internal parts (e.g., an electrostatic chuck, an edge ring, an inner wall, etc.) are required to have plasma resistance because they are exposed to a plasma atmosphere. For example, in a plasma processing apparatus used in a semiconductor device manufacturing process, the chamber and the parts are detachable to allow loading/unloading of a workpiece such as a wafer while ensuring maintenance of a vacuum state inside the apparatus. For example, a sealing member (sealing material) such as an O-ring is used at the detachable parts. Providing the plasma-resistant structure of the present disclosure to the detachable parts and the like can extend the service life of the plasma processing apparatus. In the present disclosure, a “component” for a plasma processing apparatus refers to any component, in the plasma processing apparatus, provided with the plasma-resistant structure of the present disclosure. Examples of the component include a chamber and detachable parts. Furthermore, the plasma processing apparatus itself may include the plasma-resistant structure of the present disclosure as a portion thereof. In other words, as one embodiment of the present disclosure, a plasma processing apparatus provided with a plasma-resistant structure can also be provided.

[0096]

When a crack is present in a plasma-resistant wall of a plasma processing apparatus, this wall may be regarded as a first member 2 and a second member 3. As a plasma protection member 5 and an intermediate member 4, a filler and an adhesive (for adhering the plasma protection member 5 to the first member 2 and the second member 3) may be inserted into the crack between the first member 2 and the second member 3. Thus, the plasma protection member 5 of the present disclosure can also be used as a repair material.

[0097]

(Methods for manufacturing and repairing component for plasma processing apparatus)

A component for a plasma processing apparatus (plasma-resistant structure 1) can be manufactured as follows, for example. First, a first member 2 and a second member 3 are

prepared. At this point, as described above, an intermediate member 4 is disposed between the first member 2 and the second member 3. These steps are also carried out in conventional methods for manufacturing a component for a plasma processing apparatus. In a conventional component for a plasma processing apparatus, after the first member and the second member are joined via the bonding layer, an O-ring or an adhesive (elastomer, acrylic rubber, silicone rubber, fluororubber, thermosetting resin, etc.) is provided. In contrast, in embodiments of the present disclosure, a plasma protection member 5 as described above is provided on the outer surface side of the component for the plasma processing apparatus at the end portion of the intermediate member 4. For example, the plasma protection member 5 can be installed by winding a fiber structure including fiber(s) around the outer periphery of the intermediate member 4. Furthermore, a protection material is appropriately provided along the outer periphery of the plasma protection member 5 (not shown). A method for repairing a component for a plasma processing apparatus (plasma-resistant structure 1) includes a step of winding a fiber structure around the outer periphery of the intermediate member, as in the method for manufacturing a component for a plasma processing apparatus.

[0098]

In plasma-resistant structures 1, electrostatic chucks 11, edge rings 41, and components for a plasma processing apparatus according to the present embodiments configured as described above, a first member 2, a second member 3, an intermediate member 4 disposed between the first member 2 and the second member 3, and a plasma protection member 5 including fiber(s) are provided. At least one of the first member 2 and the second member 3 has plasma resistance. The plasma protection member 5 including the fiber(s) is disposed on an outer surface side of the plasma-resistant structure 1 at an end portion of the intermediate member 4.

[0099]

A fiber structure as one embodiment of the present disclosure includes fiber(s). In a plasma-resistant structure 1 including a first member 2, a second member 3, and an intermediate member 4 disposed between the first member 2 and the second member 3, this fiber structure is disposed along an outer periphery of the intermediate member 4.

[0100]

A method for manufacturing a plasma-resistant structure 1 as one embodiment of the present disclosure includes a step of disposing an intermediate member between a first member 2 and a second member 3, and a step of winding a fiber structure around an outer periphery of the intermediate member 4.

[0101]

In a method for repairing a component for a plasma processing apparatus as one embodiment of the present disclosure, the component for a plasma processing apparatus includes a first member 2, a second member 3, and an intermediate member 4 disposed between the first member 2 and the second member 3. This repair method includes a step of winding a fiber structure including fiber(s) around an outer periphery of the intermediate member 4.

[0102]

As described above, in the plasma-resistant structures 1, since the plasma protection member 5, the first member 2, etc. have plasma resistance, this extents the service life of the intermediate member 4 and thus the plasma-resistant structure 1. Furthermore, the voids included in the plasma protection member 5 follow, for example, dimensional changes in the holding member 12 and the base 13, thereby relieving stress. As a result, the service life of the electrostatic chuck 11 can be extended. Furthermore, in a case where the plasma protection member 5 is formed by mixing fibers into a ceramic or the like, the fibers serve as an aggregate for the ceramic, and increase the strength of the plasma protection member 5 against stress. As a result, for example, the resistance to stress caused by dimensional changes in the holding member 12 and the base 13 is increased, and the service life of the electrostatic chuck 11 can be extended.

[0103]

In the plasma-resistant structures 1, the electrostatic chucks 11, the edge rings 41, the components for a plasma processing apparatus, the fiber structures, the methods for manufacturing the plasma-resistant structures 1, and the methods for repairing the components for a plasma processing apparatus according to the present embodiments, the plasma protection member 5 including fiber(s) may be disposed on the outer periphery of

the intermediate member 4. The direction in which the fiber(s) extend may be along the outer periphery of the intermediate member 4.

[0104]

In the plasma-resistant structures 1, the electrostatic chucks 11, the edge rings 41, the components for a plasma processing apparatus, the fiber structures, the methods for manufacturing the plasma-resistant structures 1, and the methods for repairing the components for a plasma processing apparatus according to the present embodiments, the plasma protection member 5 including the fiber(s) may include a fiber structure composed of fiber(s). In other words, the fiber structure may be formed from a plasma-resistant material, similarly to the plasma protection member 5.

[0105]

In the plasma-resistant structures 1, the electrostatic chucks 11, the edge rings 41, and the components for a plasma processing apparatus according to the present embodiments, the direction in which the fiber structure extends may be along the outer periphery of the intermediate member 4.

[0106]

In the plasma-resistant structures 1, the electrostatic chucks 11, the edge rings 41, the components for a plasma processing apparatus, the fiber structures, the methods for manufacturing the plasma-resistant structures 1, and the methods for repairing the components for a plasma processing apparatus according to the present embodiments, the intermediate member 4 may be a bonding layer.

[0107]

In the plasma-resistant structures 1, the electrostatic chucks 11, the edge rings, the components for a plasma processing apparatus, the fiber structures, the methods for manufacturing the plasma-resistant structures 1, and the methods for repairing the components for a plasma processing apparatus according to the present embodiments, the length of the fiber(s) in the direction in which the fiber(s) extend may be longer than the length of the outer periphery of the intermediate member 4, and the fiber(s) may be wound around the outer periphery of the intermediate member 4.

[0108]

In the plasma-resistant structures 1, the electrostatic chucks 11, the edge rings 41, the components for a plasma processing apparatus, the fiber structures, the methods for manufacturing the plasma-resistant structures 1, and the methods for repairing the components for a plasma processing apparatus according to the present embodiments, the length of the fiber structure in the direction in which the fiber structure extends may be longer than the length of the outer periphery of the intermediate member 4, and the fiber structure may be wound around the outer periphery of the intermediate member 4.

[0109]

In the plasma-resistant structures 1, the electrostatic chucks 11, the edge rings 41, the components for a plasma processing apparatus, the fiber structures, the methods for manufacturing the plasma-resistant structures 1, and the methods for repairing the components for a plasma processing apparatus according to the present embodiments, the fiber(s) may be an inorganic fiber.

[0110]

In the plasma-resistant structures 1, the electrostatic chucks 11, the edge rings 41, the components for a plasma processing apparatus, the fiber structures, the methods for manufacturing the plasma-resistant structures 1, and the methods for repairing the components for a plasma processing apparatus according to the present embodiments, the fiber structure may include at least one of a twisted yarn, a nonwoven fabric, a mesh, and a woven fabric.

[0111]

In the electrostatic chucks 11 of the present embodiments, the first member 2 may be a holding member 12 that holds a workpiece, and the second member 3 may be a base 13 that supports the holding member 12.

[0112]

In the electrostatic chucks 11 of the present embodiments, the outermost periphery of the holding member 12 may be positioned outward of an outermost portion of the plasma protection member 5, and an outermost periphery of the base 13 may be positioned outward of the outermost portion of the plasma protection member 5.

[0113]

The plasma-resistant structures 1, the electrostatic chucks 11, the edge rings 41, the components for a plasma processing apparatus, the fiber structures, the methods for manufacturing the plasma-resistant structures 1, and the methods for repairing the components for a plasma processing apparatus according to the present embodiments are not limited to the configurations and combinations described above.

[0114]

For example, the number of internal electrodes provided in the holding member 12 or the base 13 is not limited to one, and may be two.

[0115]

For example, an electrode may be provided to the edge ring portion 42 or inside the edge ring portion 42.

[0116]

For example, the edge ring 41 may further include one or more members in addition to the edge ring portion 42 and the edge ring portion 43. The intermediate member 4 may be disposed between these members, and the plasma protection member 5 may be provided on the outer periphery of the intermediate member 4.

[0117]

Hereinafter, the present disclosure will be described in more detail using Examples and Comparative Examples.

[0118]

[Electrostatic chuck manufacturing method]

[0119]

(Example 1)

An electrostatic-chuck-like plasma-resistant structure (hereinafter referred to as “electrostatic chuck”) was manufactured so as to have the configuration shown in Table 1. Specifically, a silicone adhesive (intermediate member, bonding layer) was applied to the upper surface of an aluminum base (second member; diameter: 296 mm, thickness: 30 mm) excluding a 20 mm-wide outer peripheral region, so as to have a thickness of 0.2 mm after coating. Then, an alumina plate (diameter: 297 mm, thickness: 4 mm) was bonded as a holding member (first member) onto the upper surface of the base via the silicone adhesive.

Next, an alumina fiber bundle (plasma protection member) composed of alumina fibers shown in Table 1 was wound around a recess (outer periphery of the bonding layer) surrounded by the outer peripheral end portion of the silicone adhesive (bonding layer), the alumina plate, and the base, thereby fixing the alumina fiber bundle between the alumina plate and the base. Then, by firing using a burner, the tip end of the alumina fiber bundle was bonded to a portion of the alumina fiber bundle at overlapping positions. The alumina fiber bundle was in contact with the bonding layer, and did not protrude beyond the outer peripheral end portions of the base and the alumina plate. Thereafter, the assembly was left standing for 2 hours in a constant-temperature chamber set at 120°C to cure the silicone adhesive, thereby manufacturing the electrostatic chuck.

[0120]

(Examples 2 and 3)

Electrostatic chucks of Examples 2 and 3 were manufactured as with the electrostatic chuck of Example 1 so as to have the configurations shown in Table 1. Instead of being wound around the recess surrounded by the outer peripheral end portion of the bonding layer, the alumina plate, and the base, three alumina fiber bundles (fiber length: 15 mm or 200 mm) shown in Table 1 were inserted along the entire outer periphery of the bonding layer and arranged side by side such that the extending direction of the alumina fiber bundles was along the outer periphery of the bonding layer.

[0121]

(Examples 4 to 13)

Electrostatic chucks of Examples 4 to 13 were manufactured as with the electrostatic chuck of Example 1 so as to have the configurations shown in Table 1. In Table 1, “fiber bundle 1” refers to CY-640D manufactured by Ceramic Wool Co., Ltd., “fiber bundle 2” refers to CY-1280D manufactured by Ceramic Wool Co., Ltd., “fiber bundle 3” refers to CT-2560D manufactured by Nichibi Co., Ltd., “fiber bundle 4” refers to 12-100/2 manufactured by Nippon Seisen Co., Ltd., and “fiber bundle 5” refers to T300-1000 manufactured by Toray industries, Inc. (the same applies to Table 2).

[0122]

(Comparative example 1)

An electrostatic chuck of Comparative example 1 was manufactured as with the electrostatic chuck of Example 1 so as to have the configuration shown in Table 1. The silicone adhesive was applied so as to have a thickness of 3.0 mm after coating. As the plasma protection member of Comparative example 1, a fluororubber-based O-ring (AS568-277-D manufactured by NOK Corporation; cord diameter: 3.5 mm, outer diameter: 299 mm, inner diameter: 292 mm) was used and inserted into the recess surrounded by the outer peripheral end portion of the bonding layer, the alumina plate, and the base.

[0123]

(Comparative example 2)

An electrostatic chuck of Comparative example 2 was manufactured as with the electrostatic chuck of Example 1 so as to have the configuration shown in Table 1. The plasma protection member of Comparative example 2 was formed by thermal-spraying alumina particles (SURPREX AHP50 manufactured by Fujimi Incorporated; particle size: 45 μm (manufacturer's nominal value)) from the outside of the bonding layer into the recess surrounded by the outer peripheral end portion of the bonding layer, the alumina plate, and the base.

[0124]

(Example 14)

An edge ring was manufactured so as to have the configuration shown in Table 2. Specifically, a silicone adhesive (intermediate member, bonding layer; addition-curable silicone rubber KE-8101 manufactured by Shin-Etsu Chemical Co., Ltd.) was applied to a surface of a ring-shaped alumina plate (first member; outer diameter: 340 mm, inner diameter: 300 mm, thickness: 16 mm) excluding 10 mm-wide regions at the outer and inner peripheries of the alumina plate, so as to have a thickness of 0.2 mm after coating. Then, a ring-shaped aluminum plate (second member) having the same dimensions as the alumina plate was bonded onto the silicone adhesive from above. Next, alumina fiber bundles (plasma protection members) composed of alumina fibers shown in Table 2 were respectively inserted, along the outer and inner peripheries of the bonding layer, into recesses surrounded by the alumina plate, the aluminum plate, and either the outer or inner peripheral end portions of the silicone adhesive (bonding layer). Then, by firing using a

burner, the tip end of each alumina fiber bundle was bonded to a portion of the alumina fiber bundle at overlapping positions. The alumina fiber bundles were in contact with the bonding layer, and did not protrude beyond the outer and inner peripheral end portions of the alumina plate and the aluminum plate. Thereafter, the assembly was left standing for 2 hours in a constant-temperature chamber set at 120°C to cure the silicone adhesive, thereby manufacturing the edge ring.

[0125]

(Examples 15 and 16)

Edge rings of Examples 15 and 16 were manufactured as with the edge ring of Example 14 so as to have the configurations shown in Table 2. Instead of inserting alumina fiber bundles composed of alumina fibers as the plasma protection members at the outer and inner peripheral end portions of the bonding layer, three alumina fiber bundles shown in Table 2 were inserted along the entirety of each of the outer and inner peripheral end portions of the bonding layer and arranged side by side such that the extending direction of the alumina fiber bundles was along the outer and inner peripheries of the bonding layer.

[0126]

(Examples 17 to 22)

Edge rings of Examples 17 to 22 were manufactured as with the edge ring of Example 14 so as to have the configurations shown in Table 2.

[0127]

(Comparative example 3)

An edge ring of Comparative example 3 was manufactured as with the edge ring of Example 14 so as to have the configuration shown in Table 2. In Comparative example 3, the silicone adhesive was applied so as to have a thickness of 3.0 mm after coating. As the plasma protection member, a fluororubber-based O-ring (AS568-279-D manufactured by NOK Corporation; cord diameter: 3.5 mm, outer diameter: 337 mm, inner diameter: 330 mm) was used for the outer periphery of the silicone adhesive, and a fluororubber-based O-ring (AS568-278-D manufactured by NOK Corporation; cord diameter: 3.5 mm, outer diameter: 311 mm, inner diameter: 304 mm) was used for the inner periphery of the silicone adhesive. These O-rings were respectively inserted into recesses surrounded by the

alumina plate, the aluminum plate, and either the outer or inner peripheral end portion of the silicone adhesive (bonding layer).

[0128]

(Comparative example 4)

An edge ring of Comparative example 4 was manufactured as with the edge ring of Example 14 so as to have the configuration shown in Table 2. The plasma protection members of Comparative example 4 were formed by plasma-spraying alumina particles (SURPREX AHP50 manufactured by Fujimi Incorporated; particle size: 45 μm (manufacturer's nominal value)) from the outer and inner sides of the bonding layer into recesses surrounded by the alumina plate, the aluminum plate, and either the outer or inner peripheral end portion of the bonding layer.

[0129]

[Evaluation method]

(Measurement of number of fibers in cross section after installation)

The number of fibers in cross section after installation for the electrostatic chucks and the edge rings of Examples 1 to 22 were measured under the conditions as follows. Specifically, the plasma protection member installed on each of the electrostatic chucks and the edge rings was cut in the vertical direction, and the number of fibers in cross section was measured from the resulting cross-sections using a microscope (VHX-5000, manufactured by Keyence Corporation).

(Evaluation of plasma resistance)

The electrostatic chucks and the edge rings of Examples 1 to 22 and Comparative examples 1 to 4 were subjected to plasma processing under the conditions described below. Thereafter, each plasma protection member was removed, and the end portion of the silicone adhesive was observed at a magnification of 100x using a digital microscope (VHX-6000 manufactured by Keyence Corporation). The plasma resistance was evaluated as follows: "A+" when no change in the appearance of the silicone adhesive was observed before and after the plasma processing; "A" when the outer or inner peripheral end surface of the silicone adhesive receded toward the inside of the silicone adhesive by less than 2 mm at its maximum; "B" when the outer or inner peripheral end surface of the silicone

adhesive receded toward the inside of the silicone adhesive by 2 mm or more and less than 5 mm at its maximum; “C” when the silicone adhesive remained and the outer or inner peripheral end surface of the silicone adhesive receded toward the inside of the silicone adhesive by 5 mm or more and less than 8 mm at its maximum; and “D” when the outer or inner peripheral end surface of the silicone adhesive receded toward the inside of the silicone adhesive by 8 mm or more or when the silicone adhesive completely disappeared.

[0130]

Plasma processing apparatus: Unity Me (manufactured by Tokyo Electron Ltd.)

Output of high-frequency power supply: 1000 W

Frequency of high-frequency power supply: 13.56 MHz

Output of bias power supply: none

Degree of vacuum: 300 mTorr

Oxygen gas flow rate: 400 sccm

Fluorine gas flow rate: 200 sccm

Temperature of mounting surface: 25°C

Plasma processing time: 24 hours

[0131]

(Evaluation of durability)

Evaluation of durability was performed for the electrostatic chucks and the edge rings according to Examples 1 to 22 and Comparative examples 1 to 4. Specifically, thermal cycling and plasma processing were performed under the conditions described below, and the bonding layers and the plasma protection members of the electrostatic chucks and the edge rings were evaluated for cracking, peeling, etc. In the thermal cycling test, the electrostatic chucks and the edge rings were placed in a constant-temperature chamber (TCC-151W manufactured by ESPEC Corp.) set at 0°C. Then, the temperature was increased to 120°C at a rate of 10°C/min, held at 120°C for 30 minutes, and decreased to 0°C at a rate of 10°C/min. This process was repeated for 200 cycles. Thereafter, the electrostatic chucks and the edge rings were removed from the constant-temperature chamber and installed in a plasma processing apparatus, followed by plasma processing for 10 hours. Thereafter, the appearances of the electrostatic chucks and the edge rings

were observed and evaluated. The durability was evaluated for the electrostatic chucks and the edge rings as follows: “A” when neither cracking nor peeling occurred in both the bonding layer and the plasma protection member; “B” when cracking or peeling occurred only in the plasma protection member; “C” when cracking or peeling occurred only in the bonding layer; and “D” when cracking or peeling occurred in both the bonding layer and the plasma protection member. The plasma processing conditions are listed below.

[0132]

Plasma processing apparatus: Unity Me (manufactured by Tokyo Electron Ltd.)

Output of high-frequency power supply: 1000 W

Frequency of high-frequency power supply: 13.56 MHz

Output of bias power supply: none

Degree of vacuum: 300 mTorr

Oxygen gas flow rate: 400 sccm

Fluorine gas flow rate: 200 sccm

Temperature of mounting surface: 25°C

Plasma processing time: 10 hours

[0133]

(Evaluation of particle resistance 1)

Particle resistance (particle generation ability) was evaluated for the electrostatic chucks of Examples 1 to 13 and Comparative examples 1 and 2. Specifically, a dummy wafer was placed on the mounting surface (holding member) of each electrostatic chuck, and after plasma processing, the number of particles adhering to the surface of the dummy wafer, which was in contact with the mounting surface, was calculated. Specifically, after a dummy wafer (diameter: 300 mm, thickness; 775 mm, material: silicon) was placed on the mounting surface of the electrostatic chuck, the electrostatic chuck was installed in a plasma processing apparatus, and plasma processing was performed for 24 hours. Thereafter, the electrostatic chuck was removed, and the dummy wafer was lifted from the mounting surface. Then, the number and size of particles adhering to the surface of the dummy wafer, which was in contact with the mounting surface, were measured using a wafer surface inspection system (WM-10 manufactured by TOPCON Corporation). The number

of particles having a diameter of 0.5 μm or more and less than 1.0 μm, and the number of particles having a diameter of 1.0 μm or more were measured. The particle resistance was evaluated as follows: “A” when the total number of particles was less than 1000; “B” when the number of particles was 1000 or more and less than 5000; “C” when the number of particles was 5000 or more and less than 10000; and “D” when the number of particles was 10000 or more. The plasma processing conditions are listed below.

[0134]

Plasma processing apparatus: Unity Me (manufactured by Tokyo Electron Ltd.)

Output of high-frequency power supply: 1000 W

Frequency of high-frequency power supply: 13.56 MHz

Output of bias power supply: none

Degree of vacuum: 300 mTorr

Oxygen gas flow rate: 400 sccm

Fluorine gas flow rate: 200 sccm

Temperature of mounting surface: 25°C

Plasma processing time: 24 hours

[0135]

(Evaluation of particle resistance 2)

Particle resistance was evaluated for the edge rings of Examples 14 to 22 and Comparative examples 3 and 4. Specifically, the electrostatic chuck of Example 1 was installed on the inner peripheral side of each edge ring, and a dummy wafer was placed on the mounting surface of the electrostatic chuck, followed by plasma processing. Thereafter, the number of particles adhering to the surface of the removed dummy wafer, which was in contact with the mounting surface, was calculated. Specifically, the electrostatic chuck of Example 1 was installed on the inner peripheral side of the edge ring, and a dummy wafer (diameter: 300 mm, thickness: 775 mm, material: silicon) was placed on the mounting surface of the electrostatic chuck, thereby preparing an evaluation sample. Thereafter, the evaluation sample was installed in a plasma processing apparatus, and plasma processing was performed for 24 hours. After the plasma processing, the evaluation sample was removed, and the dummy wafer was lifted from the mounting surface. Then, the number and size of

particles adhering to the surface of the dummy wafer, which was in contact with the mounting surface, were measured using a wafer surface inspection system (WM-10 manufactured by TOPCON Corporation). The number of particles having a diameter of 0.5 μm or more and less than 1.0 μm, and the number of particles having a diameter of 1.0 μm or more, were measured. The particle resistance was evaluated as follows: “A” when the total number of particles was less than 1500; “B” when the number of particles was 1500 or more and less than 5500; “C” when the number of particles was 5500 or more and less than 10500; and “D” when the number of particles was 10500 or more. The plasma processing conditions are listed below.

[0136]

Plasma processing apparatus: Unity Me (manufactured by Tokyo Electron Ltd.)

Output of high-frequency power supply: 1000 W

Frequency of high-frequency power supply: 13.56 MHz

Output of bias power supply: none

Degree of vacuum: 300 mTorr

Oxygen gas flow rate: 400 sccm

Fluorine gas flow rate: 200 sccm

Temperature of mounting surface: 25°C

Plasma processing time: 24 hours

[0137]

[Table 1]

				Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8
Bonding layer			Thickness	mm	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Plasma protection member			Type		Fiber bundle 1	Fiber bundle 1	Fiber bundle 1	Fiber bundle 1	Fiber bundle 1	Fiber bundle 1	Fiber bundle 1	Fiber bundle 1
	Fiber structure	Fiber	Diameter	μm	7	7	7	7	7	7	7	7
			Length	mm	2000	15	200	980	15400	2000	2000	2000
			Aspect ratio	-	285714	2143	28571	140000	2200000	285714	285714	285714
		Fiber bundle	Number	count	640	640	640	640	640	640	640	640
			Number of twists per meter	count	90	90	90	90	90	15	23	280
			Number of fibers in cross section after installation	count	1920	1920	1920	1280	10240	1920	1920	1920
Evaluation			Plasma resistance	mm	A+	B	A	A	A+	A	A+	A+
			Durability	-	A	A	A	A	A	A	A	B
			Particle resistance	Number of particles	A	C	B	A	A	B	B	A

[Table 1] (cont.)

				Example 9	Example 10	Example 11	Example 12	Example 13	Comparative Example 1	Comparative Example 2
Bonding layer		Thickness	mm	0.20	0.20	0.20	0.20	0.20	3.00	0.20
Plasma protection member		Type		Fiber bundle 1	Fiber bundle 2	Fiber bundle 3	Fiber bundle 4	Fiber bundle 5	O-ring	Thermal spraying
	Fiber structure: Fiber	Diameter	μm	7	7	7	12	7	-	-
		Length	mm	2000	1000	2000	4000	2000	-	-
		Aspect ratio	-	285714	142857	285714	333333	285714	-	-
	Fiber structure: Fiber bundle	Number	count	640	1280	2560	100	1000	-	-
		Number of twists per meter	count	360	90	180	250	5	-	-
		Number of fibers in cross section after installation	count	1920	3840	1920	500	2000	-	-
Evaluation		Plasma resistance	mm	B	A	A	B	B	D	B
		Durability	-	B	A	B	A	B	A+	D
		Particle resistance	Number of particles	C	A	A	A	B	B	D

[0138]

[Table 2]

					Example 14	Example 15	Example 16	Example 17	Example 18	Example 19	Example 20
Bonding layer			Thickness	mm	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Plasma protection member			Type	-	Fiber bundle 1	Fiber bundle 1	Fiber bundle 1	Fiber bundle 1	Fiber bundle 1	Fiber bundle 1	Fiber bundle 1
	Outer periphery	Fiber	Diameter	μm	7	7	7	7	7	7	7
			Length	mm	2200	15	200	1100	8160	2200	2200
			Aspect ratio	-	314286	2143	28571	157143	1165714	314286	314286
		Fiber bundle	Number	count	640	640	640	640	640	640	640
			Number of twists per meter	count	90	90	90	90	90	15	23
		Number of fibers in cross section after installation		count	1920	1920	1920	1280	5760	1920	1920
	Inner periphery	Fiber	Diameter	μm	7	7	7	7	7	7	7
			Length	mm	1980	15	200	1100	7840	2200	2200
			Aspect ratio	-	282857	2143	28571	157143	1120000	314286	314286
		Fiber bundle	Number	count	640	640	640	640	640	640	640
			Number of twists per meter	count	90	90	90	90	90	15	23
		Number of fibers in cross section after installation		count	1920	1920	1920	640	5760	1920	1920
Evaluation			Plasma resistance	mm	A+	B	A	A	A+	A	A+
			Durability	-	A	A	A	A	A	A	A
			Particle resistance	Number of particles	A	C	B	A	A	B	B

[Table 2] (cont.)

						Example 21	Example 22	Comparative example 3	Comparative example 4
Bonding layer			Thickness	mm		0.20	0.20	3.00	0.20
Plasma protection member			Type	-		Fiber bundle 1	Fiber bundle 1	O-ring	Thermal spraying
	Outer periphery	Fiber	Diameter	μm		7	7	-	-
			Length	mm		2200	2200	-	-
			Aspect ratio	-		314286	314286	-	-
		Fiber bundle	Number	count		640	640	-	-
			Number of twists per meter	count		280	360	-	-
		Number of fibers in cross section after installation		count		1920	1920	-	-
	Inner periphery	Fiber	Diameter	μm		7	7	-	-
			Length	mm		2200	2200	-	-
			Aspect ratio	-		314286	314286	-	-
		Fiber bundle	Number	count		640	640	-	-
			Number of twists per meter	count		280	360	-	-
		Number of fibers in cross section after installation		count		1920	1920	-	-

Evaluation	Plasma resistance	mm	A+	B	D	B	
	Durability	-	B	B	A+	D	
	Particle resistance	Number of particles	A	C	B	D	

[0139]

(Overall evaluation)

As shown in Table 1 and Table 2, the plasma-resistant structures (electrostatic chucks, edge rings) of the present disclosure, including the plasma protection member including fibers exhibits well-balanced plasma resistance, durability, and particle resistance, compared to the plasma-resistant structures of Comparative examples 1 to 4 including no

fibers. This indicates overall long service lives.

[0140]

Comparative examples 1 and 3 including O-rings made of fluororubber were excellent in durability, but vulnerable to plasma. In the case of a twisted yarn as in Examples, a plurality of fibers were entangled without being bonded together. Therefore, it is considered that when stress was applied, their positional relationships changed to relieve the stress. In contrast, in Comparative example 3, the structure was integrated into a single body (bulk body) and therefore unable to deform even when the positional relationships changed. This presumably resulted in cracking. In Comparative examples 2 and 4 in which the plasma protection members were formed by plasma-spraying alumina particles instead of using fibers, particle resistance was poor. Particularly in terms of durability, the plasma protection members were vulnerable to thermal stress, and cracking was observed after the evaluation.

[0141]

From the results of Examples 1 to 5 and 14 to 18, it is found that better evaluations are obtained as the fiber length (aspect ratio) becomes greater. It is also found that a shorter fiber length results in not only lower plasma resistance but also lower particle resistance. As for durability, favorable results were obtained regardless of the fiber length.

[0142]

From the results of Examples 6 to 9 and 20 to 22, it was found that if the number of twists is too large, the durability and plasma resistance decrease. The reason is considered to be as follows. That is, the fibers being fixed make stress relaxation difficult, and insufficient followability to the contact surface increases gaps from the plasma protection member to the base and the holding member. On the other hand, it is found that when the number of twists is too small, the plasma resistance and particle resistance decrease. These results suggest that the preferred number of twists (per meter) is 20 to 300. That is, by setting the number of twists within the above range, both stress relaxation and particle generation suppression can be achieved.

[0143]

From the results of Examples 10 to 11, as the fiber bundle became thicker (as the number

of fibers in the fiber bundle increases), the plasma resistance decreased. This is presumably because an increase in the number of fibers reduces the movable region of the fibers, making stress relaxation difficult, which enlarges the gaps between the base and the fiber bundle and between the holding member and the fiber bundle.

[0144]

In Example 12 using SUS fibers, the plasma resistance was low. This is presumably because the low resilience of the material resulted in gaps between the base and the holding member. The durability was a favorable result presumably because the stress relaxation properties of the fibers themselves were high. In Example 13 using carbon fibers, the durability and particle resistance were low. This is presumably because the fibers have high resilience and are prone to breakage even under low stress.

[0145]

[Electrostatic chuck manufacturing method 2]

[0146]

(Example 23)

As for Example 23 (FIG. 9), an electrostatic-chuck-like plasma-resistant structure (hereinafter referred to as “electrostatic chuck”) was manufactured so as to have the configuration shown in Table 3. Specifically, a silicone adhesive (intermediate member, bonding layer) was applied to the upper surface of an aluminum base (second member; diameter: 100 mm, thickness: 30 mm) excluding an outer peripheral region, so as to have a thickness of 100 μm after coating. Then, an alumina plate (diameter: 100 mm, thickness: 4 mm) was bonded as a holding member (first member) onto the upper surface of the base via the silicone adhesive. Next, an alumina fiber bundle (fiber structure, plasma protection member; space factor in non-installed state: 53%) composed of alumina fibers shown in Table 3 was wound four times around a recess (the outer periphery of the bonding layer) surrounded by the outer peripheral end portion of the silicone adhesive (bonding layer), the alumina plate, and the uncoated region on the base, thereby fixing the alumina fiber bundle between the alumina plate and the base. Then, by firing using a burner, the tip end of the alumina fiber bundle was bonded to a portion of the alumina fiber bundle at overlapping positions. Thereafter, the assembly was left standing for 2 hours in a constant-

temperature chamber set at 120°C to cure the silicone adhesive, thereby manufacturing the electrostatic chuck.

[0147]

(Example 24)

As for Example 24 (FIG. 10), an electrostatic chuck was manufactured so as to have the configuration shown in Table 3, as in Example 23 except that the thickness of the silicone adhesive, the space factor of the alumina fiber bundle in the non-installed state, and the number of windings of the alumina fiber bundle were changed. In Example 24, the thickness of the silicone adhesive was 565 μm, the space factor of the alumina fiber bundle in the non-installed state was 46%, and the number of windings of the alumina fiber bundle was 32.

[0148]

(Example 25)

As for Example 25, an electrostatic chuck was manufactured so as to have the configuration shown in Table 3, as in Example 23 except that the thickness of the silicone adhesive, the space factor of the alumina fiber bundle in the non-installed state, and the number of windings of the alumina fiber bundle were changed. In Example 25, the thickness of the silicone adhesive was 70 μm, the space factor of the alumina fiber bundle in the non-installed state was 51%, and the number of windings of the alumina fiber bundle was 16.

[0149]

(Examples 26 to 28)

As for Examples 26 to 28, electrostatic chucks were manufactured so as to have the configurations shown in Table 3, as in Example 23 except that the diameter of the alumina fiber bundle, the space factor of the alumina fiber bundle in the non-installed state, and the number of windings of the alumina fiber bundle were changed. In Examples 26 to 28, the diameter of the alumina fiber bundle was 120 μm, the space factor of the alumina fiber bundle in the non-installed state was 44%, and the numbers of windings of the alumina fiber bundle in Examples 26 to 28 were 1, 2, and 10, respectively.

[0150]

[Evaluation method]

(Evaluation of long-term plasma resistance)

The electrostatic chucks of Examples 23 to 28 were subjected to plasma processing under the conditions described below. Thereafter, presence or absence of damage to each plasma protection member was observed at a magnification of 100x using a digital microscope (VHX-6000 manufactured by Keyence Corporation). Next, the plasma protection member was removed from each electrostatic chuck, and the end portion of the silicone adhesive was observed at a magnification of 100x using the digital microscope. The long-term plasma resistance was evaluated as follows: “A” when no change in the appearance of the silicone adhesive was observed before and after the plasma processing; “B” when the outer or inner peripheral end surface of the silicone adhesive receded toward the inside of the silicone adhesive by less than 2 mm at its maximum; “C” when the outer or inner peripheral end surface of the silicone adhesive receded toward the inside of the silicone adhesive by 2 mm or more and less than 8 mm at its maximum; and “D” when at least one of the following conditions was met: the outer or inner peripheral end surface of the silicone adhesive receded toward the inside of the silicone adhesive by 8 mm or more; the silicone adhesive disappeared; and damage to the fiber structure was observed.

[0151]

Plasma processing apparatus: Unity Me (manufactured by Tokyo Electron Ltd.)

Output of high-frequency power supply: 1000 W

Frequency of high-frequency power supply: 13.56 MHz

Output of bias power supply: none

Degree of vacuum: 300 mTorr

Oxygen gas flow rate: 400 sccm

Fluorine gas flow rate: 200 sccm

Temperature of mounting surface: 25°C

Plasma processing time: 48 hours

Intermediate member 4: silicone adhesive

[0152]

[Table 3]

	Length H between first member and second member (silicone adhesive thickness)	Space factor of fiber structure in non-installed state	Space factor of fiber structure in region A	Space factor of fiber structure in region B	Space factor of fiber structure in region C
Unit	μm	%	%	%	%
Example 23	100	53	76	74	73
Example 24	565	46	82	81	76
Example 25	70	51	83	83	78
Example 26	100	44	73	58	29
Example 27	100	44	80	73	58
Example 28	100	44	96	88	85

Table 3 (cont.)

	Diameter D of fiber structure in non-installed state	Diameter of fiber of fiber structure	D/H	Evaluation of long-term plasma resistance
Unit	μm	μm	-	-
Example 23	150	7	1.5	A
Example 24	150	7	0.3	B
Example 25	150	7	2.1	A
Example 26	120	7	1.2	C
Example 27	120	7	1.2	B
Example 28	120	7	1.2	D Damage observed

[0153]

From Examples 23 and 25, it is found that when the fiber structure is installed while being compressed between the first member and the second member (case 1), the higher the D/H value, the greater the effect of isolating the silicone adhesive (intermediate member) from the plasma atmosphere.

[0154]

Examples 26 and 27 somewhat differed from Example 23 in the diameter of the alumina fiber bundle (fiber structure) and D/H, while the length H between the first member and the second member was the same as that of Example 23. The primary difference was the

number of windings of the fiber structure. The number of windings is considered to be substantially proportional to the length over which the fiber structure overlaps with itself in the direction facing the silicone adhesive after installation. From the result of the long-term plasma resistance evaluation, the effect of isolating or distancing the silicone adhesive from the plasma atmosphere by the fiber structure was the highest for Example 23, followed by Example 27 and Example 26. In Example 23, the space factors of the fiber structure in regions A to C (corresponding to regions A to C in FIG. 10, respectively) are all as high as 73% or more. In contrast, in Example 26, the space factor of the fiber structure is 58% in region B and 29% in region C. In other words, the region in Example 23 in which the fibers are densely present (the length over which the fiber structure overlaps with itself in the direction facing the silicone adhesive) is larger than that region in Examples 26 and 27. Presumably, this increased the length before the plasma atmosphere reaches the silicone adhesive, and that high effect of isolating or distancing the silicone adhesive from the plasma atmosphere was consequently achieved (a similar effect can also be inferred from Example 24).

[0155]

In Example 28, the diameter D of the fiber structure and the length H between the first member and the second member were the same as those of Examples 26 and 27. The primary difference was the number of windings of the fiber structure. Therefore, from the result of the long-term plasma resistance evaluation, the effect of isolating or distancing the silicone adhesive from the plasma atmosphere by the fiber structure was the highest for Example 28, followed by Example 27 and Example 26. In Example 28, the space factors of the fiber structure in regions A to C are all as high as 85% or more, and the result of long-term plasma resistance evaluation exhibited no changes in the appearance of the silicone adhesive. However, partial damage to the fiber structure was observed. In region A of Example 28, the space factor of the fiber structure was as high as 96%, and voids between fibers were minimal. Therefore, it is considered that the structure was unable to withstand the continuously generated thermal stress during the long-term plasma resistance evaluation, resulting in the partial damage to the fiber structure. Furthermore, from the results of Examples 26 and 27, it is found that if a region where fibers are densely present

exists in at least a portion of the fiber structure, the effect of isolating the silicone adhesive (intermediate member) from the plasma atmosphere can be achieved.

Description of Reference Numerals

[0156]

1, 1a, 11, 21, 31, 41: Plasma-resistant structure (electrostatic chuck, edge ring)

2, 2a, 12, 22, 32, 42: First member (holding member, edge ring portion)

32a: Upper surface of holding member

3, 13, 23, 33, 43: Second member (base, edge ring portion)

33a: Through-recess of second member

4, 14, 24a, 24b, 34, 44: Intermediate member (bonding layer)

34b: Inner surface of bonding layer

5, 15, 25, 35, 45, 45a, 45b: Plasma protection member

36: Through-hole

36a: Inner wall of through-hole

M: Insulating member

P: Lift pin

W: Workpiece

CLAIMS

[Claim 1] A plasma-resistant structure comprising:

a first member;

a second member;

an intermediate member disposed between the first member and the second member; and

a plasma protection member comprising a fiber, wherein

at least one of the first member and the second member has plasma resistance, and

the plasma protection member comprising the fiber is disposed on an outer surface side of the plasma-resistant structure at an end portion of the intermediate member.

[Claim 2] The plasma-resistant structure according to claim 1, wherein the plasma protection member comprising the fiber is disposed on an outer periphery of the intermediate member.

[Claim 3] The plasma-resistant structure according to claim 1, wherein a direction in which the fiber extends is along an outer periphery of the intermediate member.

[Claim 4] The plasma-resistant structure according to claim 1, wherein the plasma protection member comprising the fiber includes a fiber structure composed of a fiber.

[Claim 5] The plasma-resistant structure according to claim 4, wherein a direction in which the fiber structure extends is along an outer periphery of the intermediate member.

[Claim 6] The plasma-resistant structure according to claim 1, wherein the intermediate member is a bonding layer.

[Claim 7] The plasma-resistant structure according to claim 1, wherein

a length of the fiber in a direction in which the fiber extends is longer than a length of an outer periphery of the intermediate member, and

the fiber is wound around the outer periphery of the intermediate member.

[Claim 8] The plasma-resistant structure according to claim 4, wherein

a length of the fiber structure in a direction in which the fiber structure extends is longer than a length of an outer periphery of the intermediate member, and

the fiber structure is wound around the outer periphery of the intermediate member.

[Claim 9] The plasma-resistant structure according to claim 1, wherein the fiber is an inorganic fiber.

[Claim 10] The plasma-resistant structure according to claim 4, wherein the fiber structure includes at least one of a twisted yarn, a nonwoven fabric, a mesh, and a woven fabric.

[Claim 11] An electrostatic chuck comprising the plasma-resistant structure according to claim 1, wherein

the first member is a holding member configured to hold an object to be held, and

the second member is a base configured to support the holding member.

[Claim 12] The electrostatic chuck according to claim 11, wherein an outermost periphery of the holding member is positioned outward of an outermost portion of the plasma protection member.

[Claim 13] The electrostatic chuck according to claim 11, wherein an outermost periphery of the base is positioned outward of an outermost portion of the plasma protection member.

[Claim 14] An edge ring comprising the plasma-resistant structure according to claim

1.

[Claim 15] A component for a plasma processing apparatus, comprising the plasma-resistant structure according to claim 1.

[Claim 16] A fiber structure comprising a fiber, wherein

in a plasma-resistant structure comprising a first member, a second member, an intermediate member disposed between the first member and the second member, and the fiber structure,

the fiber structure is disposed along an outer periphery of the intermediate member.

[Claim 17] A method for manufacturing a plasma-resistant structure comprising a first member, a second member, an intermediate member disposed between the first member and the second member, and a fiber structure comprising a fiber,

the method comprising:

disposing the intermediate member between the first member and the second member; and

winding the fiber structure around an outer periphery of the intermediate member.

[Claim 18] A method for repairing a component for a plasma processing apparatus, the component comprising a first member, a second member, and an intermediate member disposed between the first member and the second member,

the method comprising winding a fiber structure comprising a fiber around an outer periphery of the intermediate member.