(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 037 440 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
03.08.2022 Bulletin 2022/31

(21) Application number: **19947409.9**

(22) Date of filing: **27.09.2019**

(51) International Patent Classification (IPC):
H05H 1/26 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
H05H 1/26

(86) International application number:
PCT/JP2019/038099

(87) International publication number:
WO 2021/059469 (01.04.2021 Gazette 2021/13)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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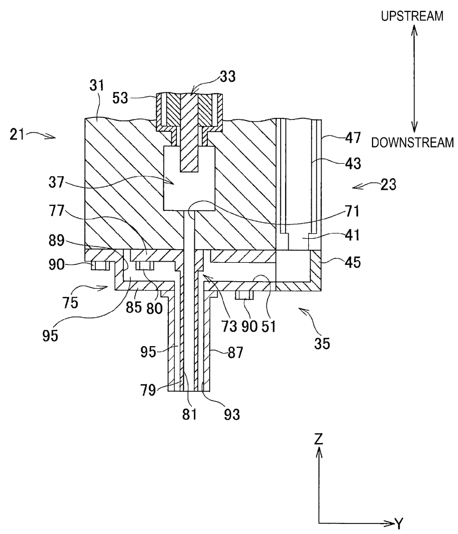
(54) PLASMA GENERATION DEVICE AND PLASMA TREATMENT METHOD

(57) A plasma generation device includes a device main body formed with a reaction chamber for plasmatizing a processing gas, a ceramic nozzle formed with a first ejection port for ejecting a plasma gas that is plasmatized in the reaction chamber, and a metal nozzle cover in which a second ejection port for ejecting a gas so as to cover the plasma gas is formed to cover the first ejection port.

[Fig. 4]



EP 4 037 440 A1

Description

Technical Field

[0001] The present disclosure relates to a plasma generation device or the like for ejecting a plasma gas.

Background Art

[0002] Examples of a plasma generation device include a structure in which a processing gas that is plasmatized in a reaction chamber, and the plasma gas that is plasmatized is ejected from an ejection port formed in a nozzle or the like. An example of such plasma generation devices is described in the following Patent Literature.

Patent Literature

[0003] Patent Literature 1: International Publication No. WO2015/141768

Summary of the Invention

Technical Problem

[0004] An object of the present specification is to improve the usefulness of a plasma generation device having a structure in which a plasma gas is ejected from an ejection port.

Solution to Problem

[0005] In order to solve the above-mentioned problems, the present specification discloses a plasma generation device including: a device main body in which a reaction chamber for plasmatizing a processing gas is formed; a ceramic nozzle in which a first ejection port for ejecting a plasma gas that is plasmatized in the reaction chamber is formed; and a metal nozzle cover in which a second ejection port for ejecting a gas so as to cover the plasma gas is formed to cover the first ejection port.

[0006] In addition, the present specification discloses a plasma generation device including: a device main body in which a reaction chamber for plasmatizing a processing gas is formed; a nozzle in which a first ejection port for ejecting a plasma gas that is plasmatized in the reaction chamber is formed, and which is provided in the device main body; and a nozzle cover which is provided in the device main body so as to cover the nozzle, and in which a second ejection port for ejecting the plasma gas ejected from the first ejection port to an outside is formed, in which the nozzle cover includes a ceramic cover main body provided in the device main body, and a metal cover section in which the second ejection port is formed and which is provided in the cover main body.

[0007] In addition, the present specification discloses a plasma treatment method including: a plasma gas ejecting step of ejecting a plasma gas from a first ejection port toward a treatment target object; and a shielding gas ejecting step of shielding the plasma gas by ejecting a shielding gas from a second ejection port formed in a metal member toward the plasma gas ejected from the first ejection port.

Advantageous Effect of the Invention

[0008] According to the present disclosure, it is possible to improve the usefulness of the plasma generation device having the structure in which the plasma gas is ejected from the ejection port.

Brief Description of Drawings

[0009]

Fig. 1 is a view illustrating a plasma device.
Fig. 2 is a perspective view illustrating a plasma head.
Fig. 3 is a sectional view of the plasma head cut in an X direction and a Z direction at positions of an electrode and a body-side plasma path.
Fig. 4 is a sectional view in line AA of Fig. 3.
Fig. 5 is a perspective view of a nozzle cover.
Fig. 6 is a perspective view of a nozzle cover.

Description of Embodiments

[0010] Hereinafter, as exemplary embodiments of the present invention, examples of the present invention will be described in detail with reference to the drawings.

[0011] As illustrated in Fig. 1, plasma device 10 includes plasma head 11, robot 13, and control box 15. Plasma head 11 is attached to robot 13. Robot 13 is, for example, a serial link-type robot (may also be referred to as a multi-joint-type robot). Plasma head 11 is configured to be capable of irradiating plasma gas in a state where plasma head 11 is held at a tip of robot 13. Plasma head 11 is configured to be three-dimensionally movable in accordance with the driving of robot 13.

[0012] Control box 15 is configured mainly by a computer, and collectively controls plasma device 10. Control box 15 has power source section 15A for supplying electric power to plasma head 11 and gas supply section 15B for supplying gas to plasma head 11. Power source section 15A is connected to plasma head 11 via a power cable (not illustrated). Power source section 15A changes a voltage to be applied to electrode 33 (refer to Figs. 3 and 4) of plasma head 11 based on the control of control box 15.

[0013] Gas supply section 15B is connected to plasma head 11 via multiple (four in the present embodiment) gas tubes 19. Gas supply section 15B supplies a reaction gas, a carrier gas, and a heat gas, which will be described later, to plasma head 11 based on the control of control box 15. Control box 15 controls gas supply section 15B, and controls an amount or the like of the gas supplied from gas supply section 15B to plasma head 11. Therefore, robot 13 operates based on the control of control box 15 to irradiate treatment target object W placed on table 17 with the plasma gas from plasma head 11.

[0014] Control box 15 includes operation section 15C having a touch panel and various switches. Control box 15 displays various setting screens, operation states (for example, a gas supply state, and the like), and the like on the touch panel of operation section 15C. In addition, control box 15 receives various types of information by operation inputs to operation section 15C.

[0015] As illustrated in Fig. 2, plasma head 11 includes plasma generation section 21, heat gas supply section 23, and the like. Plasma generation section 21 plasmatizes the processing gas supplied from gas supply section 15B (refer to Fig. 1) of control box 15 to generate plasma gas. Heat gas supply section 23 heats the gas supplied from gas supply section 15B to generate heat gas. Plasma head 11 of the present embodiment ejects the plasma gas generated in plasma generation section 21 to treatment target object W illustrated in Fig. 1 together with the heat gas generated by heat gas supply section 23. The processing gas is supplied to plasma head 11 from an upstream side to a downstream side in a direction of an arrow illustrated in Fig. 2. Plasma head 11 may have a configuration in which heat gas supply section 23 is not provided. That is, the plasma device of the present disclosure may have a configuration in which the heat gas is not used.

[0016] As illustrated in Fig. 3 and Fig. 4, plasma generation section 21 includes head main body section 31, a pair of electrodes 33, plasma irradiation section 35, and the like. Fig. 3 is a sectional view cut along with positions of the pair of electrodes 33 and multiple body-side plasma paths 71 described later, and Fig. 4 is a sectional view in line AA of Fig. 3. head main body section 31 is formed of ceramic having a high heat resistance, and reaction chamber 37 for generating plasma gas is formed in an inside of head main body section 31. Each of the pair of electrodes 33 has, for example, a cylindrical shape, and is fixed in a state where a tip portion thereof protrudes into reaction chamber 37. In the following description, the pair of electrodes 33 may be simply referred to as electrode 33. In addition, a direction in which the pair of electrodes 33 are arranged is referred to as an X direction, a direction in which plasma generation section 21 and heat gas supply section 23 are arranged is referred to as a Y direction, and an axial direction of cylindrical electrode 33 is referred to as a Z direction. In the present embodiment, the X direction, the Y direction, and the Z direction are directions orthogonal to each other.

[0017] Heat gas supply section 23 includes gas pipe 41, heater 43, connection section 45, and the like. Gas pipe 41 and heater 43 are attached to an outer peripheral surface of head main body section 31 and are covered with cover 47 illustrated in Fig. 4. Gas pipe 41 is connected to gas supply section 15B of control box 15 via gas tube 19 (refer to Fig. 1). Gas (for example, air) is supplied to gas pipe 41 from gas supply section 15B. Heater 43 is attached to an intermediate portion of gas pipe 41. Heater 43 warms the gas flowing through gas pipe 41 to generate heat gas.

[0018] As illustrated in Fig. 4, connection section 45 connects gas pipe 41 to plasma irradiation section 35. In a state where plasma irradiation section 35 is attached to head main body section 31, a first end portion of connection section 45 is connected to gas pipe 41, and a second end portion thereof is connected to heat gas flow path 51 formed in plasma irradiation section 35. Heat gas is supplied to heat gas flow path 51 via gas pipe 41.

[0019] As illustrated in Fig. 4, a part of an outer periphery portion of electrode 33 is covered with electrode cover 53 made of an insulator such as ceramic. Electrode cover 53 has a substantially hollow tubular shape, and openings are formed at both end portions in a longitudinal direction. A gap between an inner peripheral surface of electrode cover 53 and an outer peripheral surface of electrode 33 functions as gas flow path 55. An opening of electrode cover 53 on a downstream side is connected to reaction chamber 37. A lower end of electrode 33 protrudes from the opening of electrode cover 53 on the downstream side.

[0020] Reaction gas flow path 61 and a pair of carrier gas flow paths 63 are formed in the inside of head main body section 31. Reaction gas flow path 61 is provided substantially at a center portion of head main body section 31, is connected to gas supply section 15B via gas tube 19 (refer to Fig. 1), and allows the reaction gas supplied from gas supply section 15B to flow into reaction chamber 37. The pair of carrier gas flow paths 63 are disposed at positions where reaction gas flow path 61 is interposed therebetween in the X direction. Each of the pair of carrier gas flow paths 63 is connected to gas supply section 15B via gas tube 19 (refer to Fig. 1), so that the carrier gas is supplied from gas supply section 15B. Carrier gas flow path 63 allows the carrier gas to flow into reaction chamber 37 via gas flow path 55.

[0021] As the reaction gas (refer tod gas), oxygen (O2) can be employed. Gas supply section 15B allows, for example, a mixed gas (for example, dry air (Air)) of oxygen and nitrogen (N2) to flow into between electrodes 33 of reaction chamber 37 via reaction gas flow path 61. Hereinafter, this mixed gas may be referred to as the reaction gas for convenience, and oxygen may be referred to as the refer tod gas. As the carrier gas, nitrogen can be employed. Gas supply section 15B allows the carrier gas to flow from each of gas flow paths 55 so as to surround each of the pair of electrodes 33.

[0022] An AC voltage is applied to the pair of electrodes 33 from power source section 15A of control box 15. By applying the voltage, for example, as illustrated in Fig. 4, pseudo arc A is generated between lower ends of the pair of electrodes 33 in reaction chamber 37. When the reaction gas passes through pseudo arc A, the reaction gas is plasmatized. Accordingly, the pair of electrodes

33 generate discharge of pseudo arc A, plasmatize the reaction gas, and generate the plasma gas.

[0023] In addition, multiple (six in the present embodiment) body-side plasma paths 71 arranged at intervals in the X direction and extending in the Z direction are formed in a portion of head main body section 31 on the downstream side of reaction chamber 37. An upstream end portion of each of multiple body-side plasma paths 71 is connected to reaction chamber 37.

[0024] Plasma irradiation section 35 includes nozzle 73, nozzle cover 75, and the like. Nozzle 73 is generally T-shaped in side view from the X direction, and includes nozzle main body 77 and nozzle tip 79. Nozzle 73 is an integral object of nozzle main body 77 and nozzle tip 79, and is formed of ceramic having a high heat resistance. Nozzle main body 77 has a generally flange shape and is fixed to a lower surface of head main body section 31 by bolt 80. Nozzle tip 79 has a shape extending downward from a lower surface of nozzle main body 77. Nozzle 73 is formed with multiple (six in the present embodiment) nozzle-side plasma paths 81 that penetrate nozzle main body 77 and nozzle tip 79 in the vertical direction, that is, the Z direction, and multiple nozzle-side plasma paths 81 are arranged at intervals in the X direction. Multiple nozzle-side plasma paths 81 are formed at the same positions as multiple body-side plasma paths 71 in the Z direction. Therefore, body-side plasma path 71 and nozzle-side plasma path 81 communicate with each other.

[0025] As illustrated in Figs. 4 to 6, nozzle cover 75 is generally T-shaped in side view from the X direction, and includes cover main body 85 and cover tip 87. Cover main body 85 and cover tip 87 are separate members, cover main body 85 is formed of ceramic, and cover tip 87 is formed of metal, specifically, stainless steel.

[0026] Cover main body 85 is generally plate-shaped in plate thickness, and recess 89 having a shape open to an upper surface and recessed in the Z direction is formed in cover main body 85. Cover main body 85 is fixed to the lower surface of head main body section 31 by bolts 90 so that nozzle main body 77 of nozzle 73 is housed in recess 89. In addition, heat gas flow path 51 is formed in cover main body 85 so as to extend in the Y direction, a first end portion of heat gas flow path 51 is open to recess 89, and a second end portion of heat gas flow path 51 is open to a side surface of cover main body 85. An end portion of heat gas flow path 51 that is open to the side surface of cover main body 85 is connected to connection section 45 of heat gas supply section 23.

[0027] Cover tip 87 has a plate shape having a thickness dimension equivalent to a thickness dimension of cover main body 85, and is fixed to the lower surface of cover main body 85 by bolts 91 so as to extend downward from the lower surface of cover main body 85. One through-hole 93 penetrating in the Z direction is formed in cover tip 87, and an upper end portion of through-hole 93 communicates with recess 89 of cover main body 85. Nozzle tip 79 of nozzle 73 is inserted into through-hole 93. Therefore, nozzle 73 is entirely covered with nozzle cover 75. The lower end of nozzle tip 79 of nozzle 73 and the lower end of cover tip 87 of nozzle cover 75 are located at the same height.

[0028] In a state where nozzle 73 is covered with nozzle cover 75, nozzle main body 77 of nozzle 73 is located in an inside of recess 89 of nozzle cover 75, and nozzle tip 79 of nozzle 73 is located in through-hole 93 of nozzle cover 75. In such a state, a gap exists between recess 89 and nozzle main body 77, and between through-hole 93 and nozzle tip 79, and the gap functions as heat gas output path 95. The heat gas is supplied to heat gas output path 95 via heat gas flow path 51.

[0029] According to such a structure, the plasma gas generated in reaction chamber 37 flows through body-side plasma path 71 and nozzle-side plasma path 81 together with the carrier gas, and is ejected from opening 81A at the lower end of nozzle-side plasma path 81. The heat gas supplied from gas pipe 41 to heat gas flow path 51 flows through heat gas output path 95. The heat gas functions as a shielding gas for protecting the plasma gas. The heat gas flows through heat gas output path 95, and is ejected from opening 95A at the lower end of heat gas output path 95 along the ejection direction of the plasma gas. At this time, the heat gas is ejected so as to surround the periphery of the plasma gas ejected from opening 81A of nozzle-side plasma path 81. In this manner, by ejecting the heated heat gas to the periphery of the plasma gas, the efficiency (wettability or the like) of the plasma gas can be enhanced.

[0030] Plasma device 10 is an example of a plasma generation device. Heat gas supply section 23 is an example of an ejection device. Head main body section 31 is an example of a device main body. Reaction chamber 37 is an example of a reaction chamber. Nozzle 73 is an example of a nozzle. Nozzle cover 75 is an example of a nozzle cover. Nozzle main body 77 is an example of a nozzle main body. Nozzle tip 79 is an example of a nozzle tip. Opening 81A of nozzle-side plasma path 81 is an example of a first ejection port. Cover main body 85 is an example of a cover main body. Cover tip 87 is an example of a cover section. Opening 95A of heat gas output path 95 is an example of a second ejection port. The heat gas is an example of the sealing gas.

[0031] Thus, the present embodiment, which has been described heretofore, provides the following effects.

[0032] In plasma head 11, ceramic nozzle 73 is covered with nozzle cover 75 having metal cover tip 87. Therefore, it is possible to prevent nozzle 73 from being damaged. That is, since nozzle 73 is formed of ceramic, it is brittle and susceptible to damage. On the other hand, cover tip 87 serving as a tip portion of nozzle cover 75 is formed of a metal and is not easily damaged. Therefore, even when the tip of plasma head 11 comes into contact with treatment target object W or the like during the plasma irradiation by plasma head 11 or the like, nozzle 73 is protected by metal nozzle cover 75, so that nozzle 73 is prevented from being damaged. In addition, ceramic is relatively expensive, but metal is inexpensive. Accordingly, even if cover tip 87 is damaged, deformed, or the like, cover tip 87 can be exchanged at a reduced cost.

[0033] As described above, nozzle cover 75 includes cover main body 85 and cover tip 87, cover main body 85 is formed of ceramic, and cover tip 87 is formed of stainless steel. Therefore, it is possible to secure appropriate plasmatization and to achieve cost reduction. That is, although the cost can be reduced by forming the entire nozzle cover with metal, if the upper end portion of the nozzle cover closer to reaction chamber 37 of head main body section 31, that is, cover main body 85 is made of metal, discharge may generate in the periphery of cover main body 85 by the application to electrode 33 in reaction chamber 37. In such a case, it is not possible to secure appropriate plasmatization by discharge in a region other than reaction chamber 37. Accordingly, cover main body 85 closer to reaction chamber 37 is formed of ceramic, and cover tip 87 distant from reaction chamber 37 is formed of metal. Therefore, it is possible to secure appropriate plasmatization and to achieve cost reduction.

[0034] In other words, metal cover tip 87 is shaped so as to extend in a direction away from cover main body 85. That is, metal cover tip 87 has a shape extending in a direction away from reaction chamber 37. Therefore, it is possible to further suitably prevent discharge in a region other than reaction chamber 37, and it is possible to further secure appropriate plasmatization.

[0035] Nozzle tip 79 of nozzle 73 also has a shape extending in a direction away from nozzle main body 77, that is, downward, similarly to cover tip 87 of nozzle cover 75. Nozzle tip 79 extending downward is inserted in an inside of cover tip 87 extending downward. Therefore, the plasma gas ejected from opening 81A of nozzle tip 79 can be appropriately ejected to the outside of nozzle cover 75.

[0036] In plasma head 11, heated heat gas flows between nozzle 73 and nozzle cover 75, so that the heated heat gas is ejected to the periphery of the plasma gas. Therefore, as described above, the efficiency (wettability or the like) of the plasma gas can be enhanced.

[0037] The present disclosure is not limited to the above embodiments, and can be practiced in various forms where various modifications and improvements are made based on the knowledge of those skilled in the art. Specifically, for example, in plasma head 11, although the heat gas flows between nozzle 73 and nozzle cover 75, the heat gas need not to flow. That is, nozzle cover 75 may be disposed only as a cover for protecting nozzle 73.

[0038] In the above embodiments, the plasma gas and the heat gas are ejected from one plasma head 11, but the plasma gas and the heat gas may be ejected from two heads. That is, the plasma gas may be ejected from one head, and the heat gas may be ejected from a head different from the head. In addition, nozzle-side plasma path 81 and heat gas output path 95 may be formed at different positions on one head, and the plasma gas and the heat gas may be ejected from the respective paths.

[0039] In the above embodiments, nozzle 73 and nozzle cover 75 are fixed to head main body section 31, but may be simply provided. That is, nozzle main body 77 may be provided in head main body section 31. Nozzle tip 79 may also be provided in nozzle main body 77.

Reference Signs List

[0040] 10: plasma device (plasma generation device), 23: heat gas supply section (ejection device), 31: head main body section (device main body), 37: reaction chamber, 73: nozzle, 75: nozzle cover, 77: nozzle main body, 79: nozzle tip, 81A: opening (first ejection port), 85: cover main body, 87: cover tip (cover section), 95A: opening (second ejection port)

Claims

1. A plasma generation device comprising:

    a device main body in which a reaction chamber for plasmatizing a processing gas is formed;
    a ceramic nozzle in which a first ejection port for ejecting a plasma gas that is plasmatized in the reaction chamber is formed; and
    a metal nozzle cover in which a second ejection port for ejecting a gas so as to cover the plasma gas is formed to cover the first ejection port.

2. A plasma generation device comprising:

    a device main body in which a reaction chamber for plasmatizing a processing gas is formed;
    a nozzle in which a first ejection port for ejecting a plasma gas that is plasmatized in the reaction chamber is formed, and which is provided in the device main body; and
    a nozzle cover which is provided in the device main body so as to cover the nozzle, and in which a second ejection port for ejecting the plasma gas ejected from the first ejection port to an outside is formed;
    wherein the nozzle cover includes
    a ceramic cover main body provided in the device main body, and
    a metal cover section in which the second ejection port is formed and which is provided in the cover main body.

3. The plasma generation device according to claim 2, wherein the cover section has a shape extending in a direction away from the cover main body.

4. The plasma generation device according to claim 2 or 3,

wherein the nozzle includes

a nozzle main body fixed to the device main body, and

a nozzle tip in which the first ejection port is formed and which is fixed to the nozzle main body, and

the nozzle tip has a shape extending in a direction away from the nozzle main body, and is inserted into the cover section.

5. The plasma generation device according to any one of claims 2 to 4, further comprising:

an ejection device configured to eject a shielding gas into the nozzle cover,

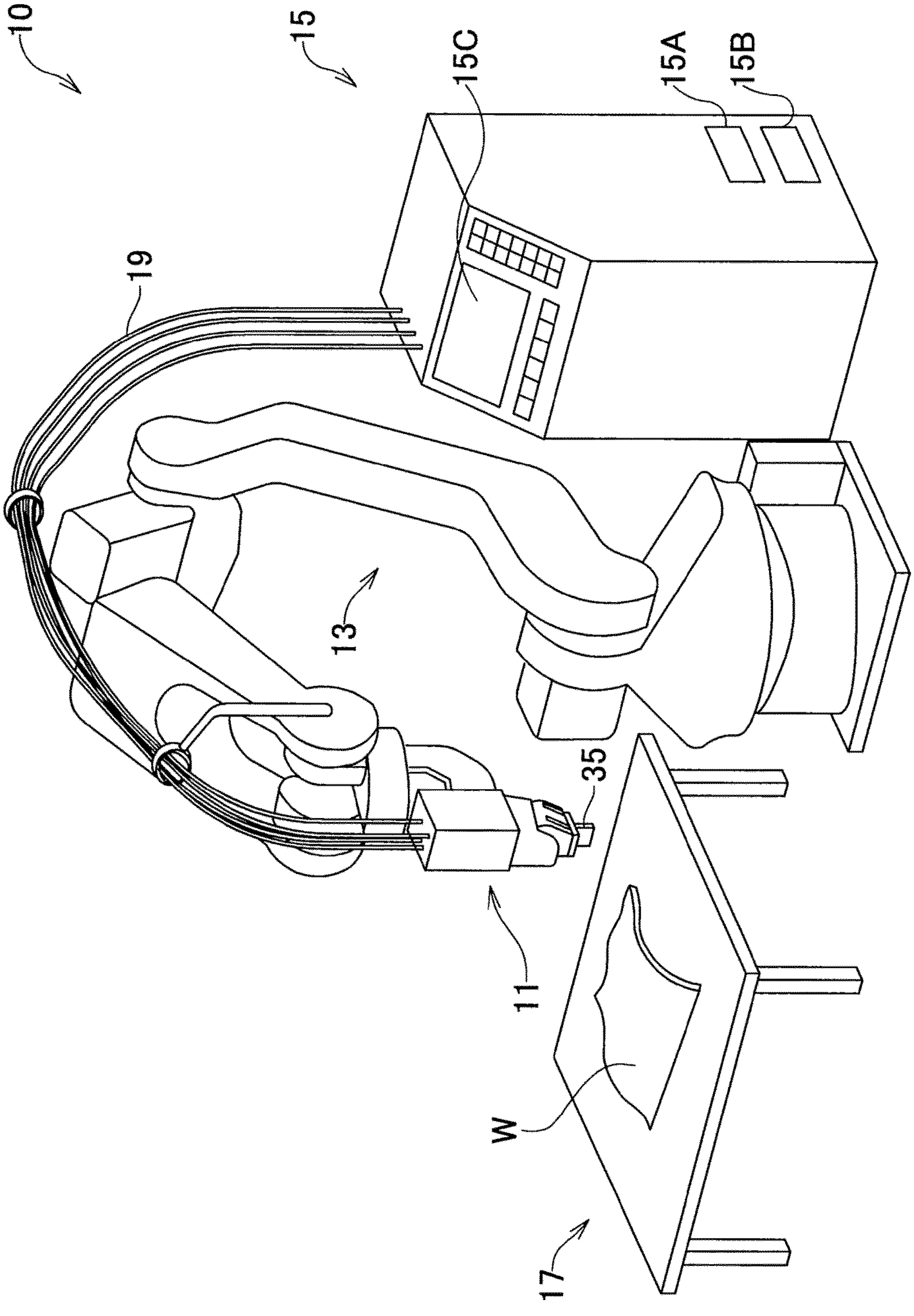
wherein the plasma gas ejected from the second ejection port to the outside of the nozzle cover is shielded by the sealing gas.

6. A plasma treatment method comprising:

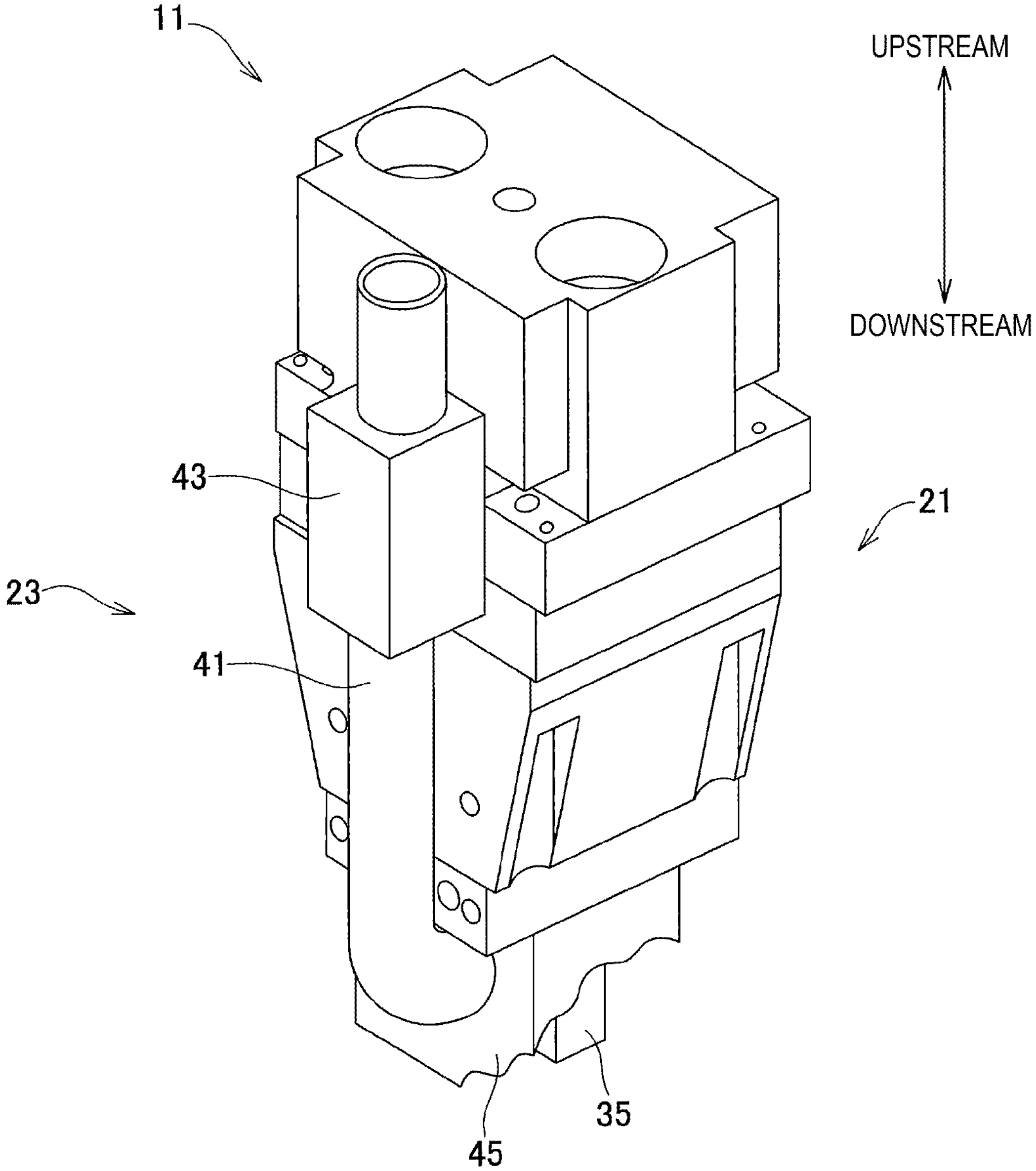
a plasma gas ejecting step of ejecting a plasma gas from a first ejection port toward a treatment target object; and

a shielding gas ejecting step of shielding the plasma gas by ejecting a shielding gas from a second ejection port formed in a metal member toward the plasma gas ejected from the first ejection port.

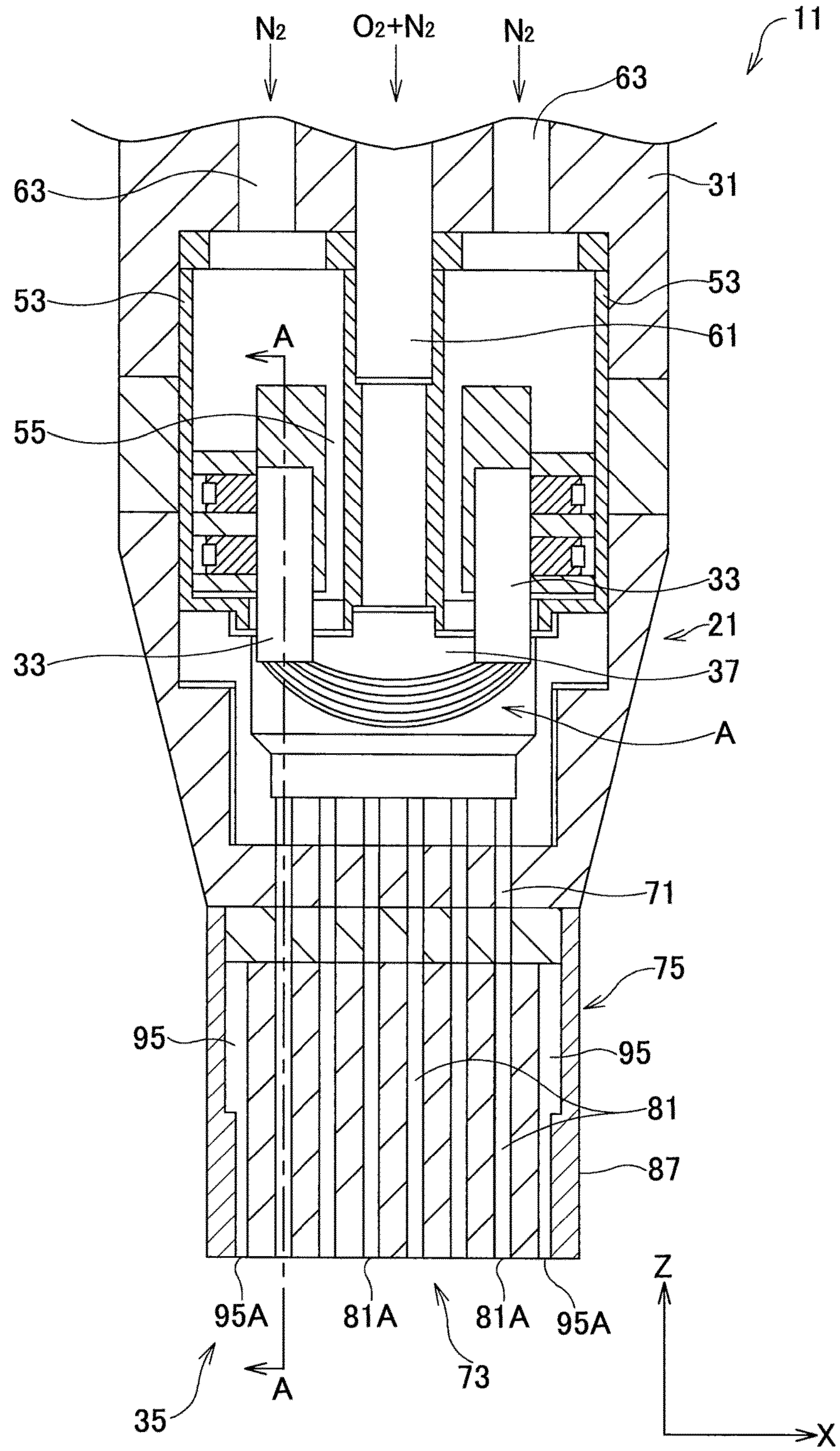
[Fig. 1]



[Fig. 2]



[Fig. 3]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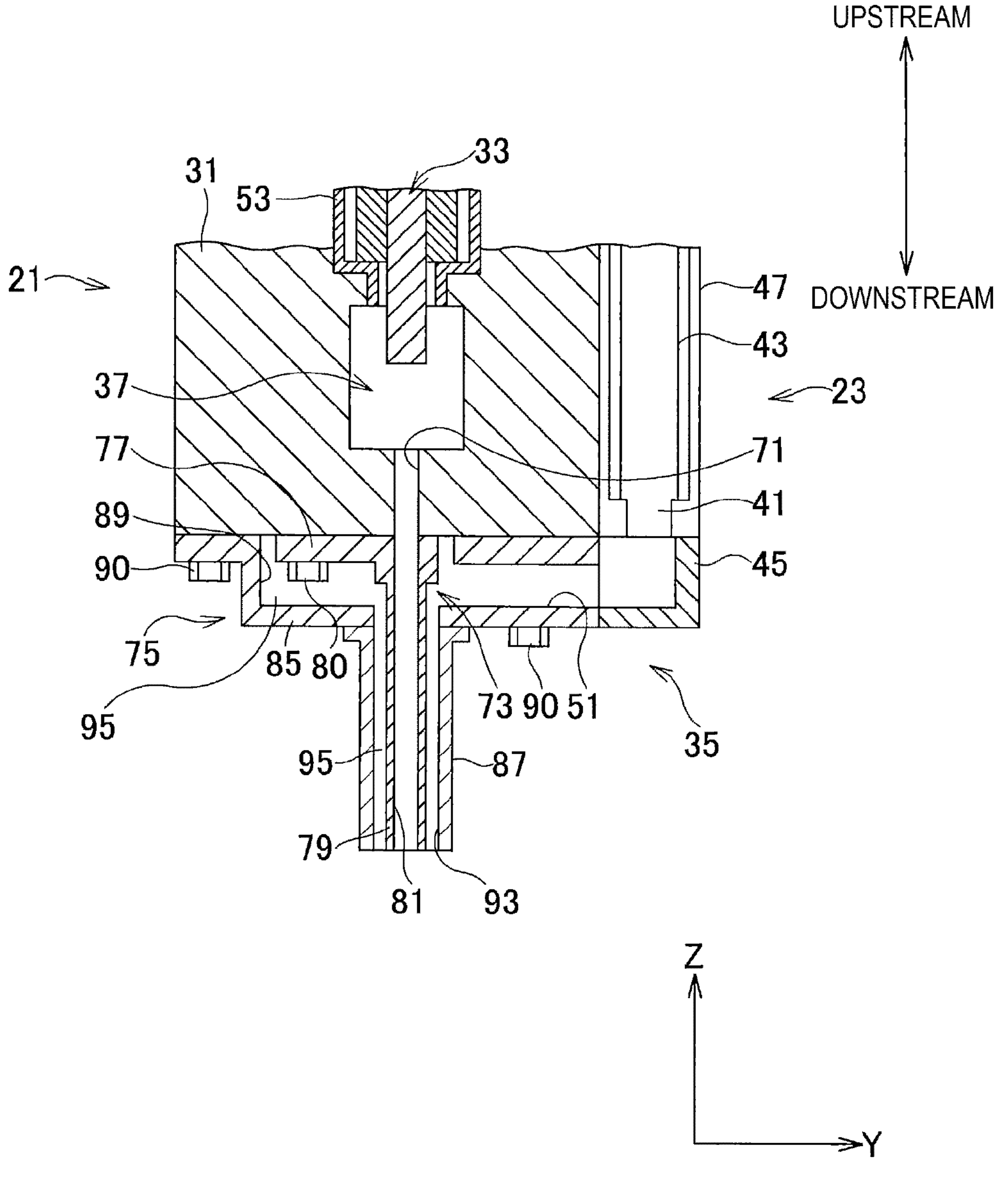
[Fig. 4]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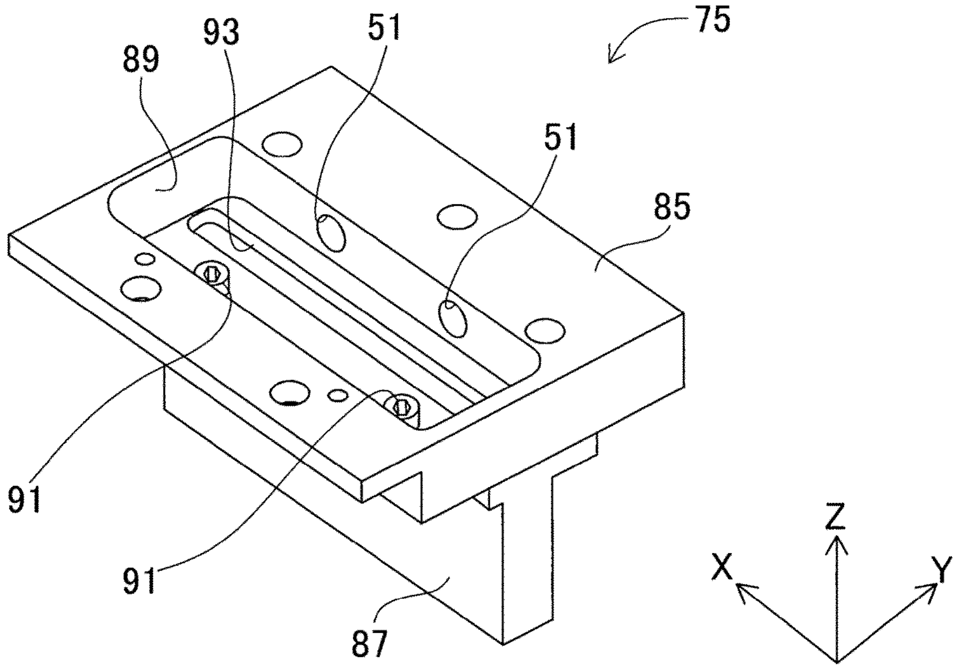
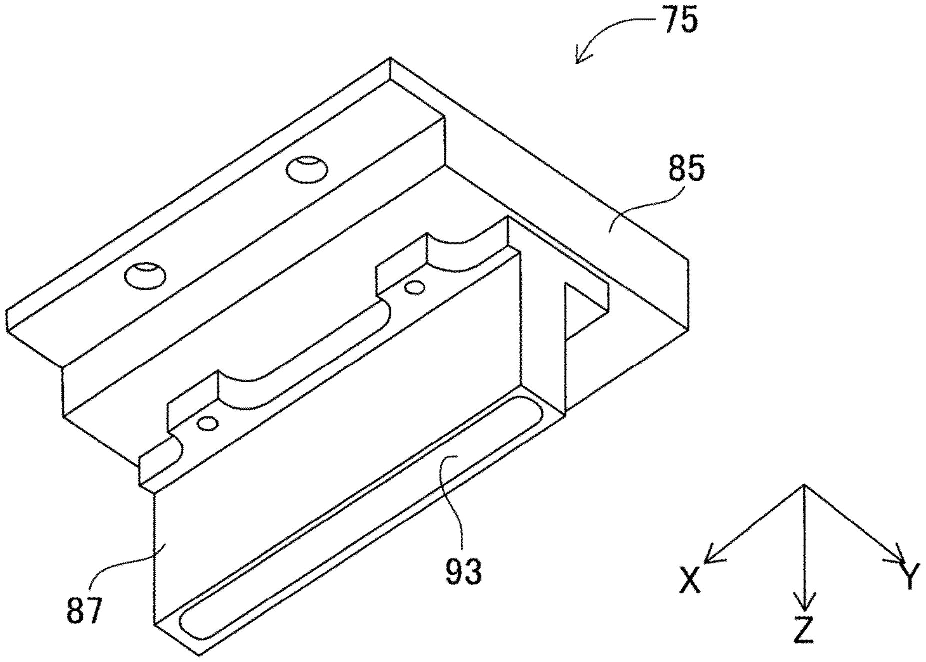
[Fig. 5]



[Fig. 6]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/038099

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. H05H1/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. H05H1/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 5-174994 A (ORIGIN ELECTRIC CO., LTD.) 13 July 1993, examples, fig. 1-2 (Family: none)	1-4 5-6
Y	WO 2019/180839 A1 (FUJI CORPORATION) 26 September 2019, paragraphs [0021], [0024], fig. 2-3 (Family: none)	1-6

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 December 2019 (03.12.2019)	17 December 2019 (17.12.2019)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/038099

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 021216/1980 (Laid-open No. 126981/1981) (HITACHI SEIKO, LTD.) 26 September 1981, page 8, lines 1-4 (Family: none)	1, 6
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 050186/1981 (Laid-open No. 165370/1982) (HITACHI SEIKO, LTD.) 18 October 1982, page 7, lines 13-15, page 7, line 18 to page 8, line 4, fig. 2 (Family: none)	2-5

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2015141768 A **[0003]**