INSTRUCTIONS

JEOL

Built-in Plasma Source
BS－80011BPG

JEOL LTD. ／ 日本電子

Tokyo Japan

BP2190005
(BS21900)

NOTICE

- This instrument generates, uses, and can radiate the energy of radio frequency and, if not installed and used in accordance with the instruction manual, may cause harmful interference to the environment, especially radio communications.
- The following actions must be avoided without prior written permission from JEOL Ltd. or its subsidiary company responsible for the subject (hereinafter referred to as "JEOL"): modifying the instrument; attaching products other than those supplied by JEOL; repairing the instrument, components and parts that have failed, such as replacing pipes in the cooling water system, without consulting your JEOL service office; and adjusting the specified parts that only field service technicians employed or authorized by JEOL are allowed to adjust, such as bolts or regulators which need to be tightened with appropriate torque. Doing any of the above might result in instrument failure and/or a serious accident. If any such modification, attachment, replacement or adjustment is made, all the stipulated warranties and preventative maintenances and/or services contracted by JEOL or its affiliated company or authorized representative will be void.
- Replacement parts for maintenance of the instrument functionality and performance are retained and available for seven years from the date of installation. Thereafter, some of those parts may be available for a certain period of time, and in this case, an extra service charge may be applied for servicing with those parts. Please contact your JEOL service office for details before the period of retention has passed.
- In order to ensure safety in the use of this instrument, the customer is advised to attend to daily maintenance and inspection. In addition, JEOL strongly recommends that the customer have the instrument thoroughly checked up by field service technicians employed or authorized by JEOL, on the occasion of replacement of expendable parts, or at the proper time and interval for preventative maintenance of the instrument. Please note that JEOL will not be held responsible for any instrument failure and/or serious accident occurred with the instrument inappropriately controlled or managed for the maintenance.
- After installation or delivery of the instrument, if the instrument is required for the relocation whether it is within the facility, transportation, resale whether it is involved with the relocation, or disposition, please be sure to contact your JEOL service office. If the instrument is disassembled, moved or transported without the supervision of the personnel authorized by JEOL, JEOL will not be held responsible for any loss, damage, accident or problem with the instrument. Operating the improperly installed instrument might cause accidents such as water leakage, fire, and electric shock.
- The information described in this manual, and the specifications and contents of the software described in this manual are subject to change without prior notice due to the ongoing improvements made in the instrument.
- Every effort has been made to ensure that the contents of this instruction manual provide all necessary information on the basic operation of the instrument and are correct. However, if you find any missing information or errors on the information described in this manual, please advise it to your JEOL service office.
- In no event shall JEOL be liable for any direct, indirect, special, incidental or consequential damages, or any other damages of any kind, including but not limited to loss of use, loss of profits, or loss of data arising out of or in any way connected with the use of the information contained in this manual or the software described in this manual. Some countries do not allow the exclusion or limitation of incidental or consequential damages, so the above may not apply to you.
- This manual and the software described in this manual are copyrighted, all rights reserved by JEOL and/or third-party licensors. Except as stated herein, none of the materials may be copied, reproduced, distributed, republished, displayed, posted or transmitted in any form or by any means, including, but not limited to, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of JEOL or the respective copyright owner.
- When this manual or the software described in this manual is furnished under a license agreement, it may only be used or copied in accordance with the terms of such license agreement.

- In some cases, this instrument, the software, and the instruction manual are controlled under the “Foreign Exchange and Foreign Trade Control Law” of Japan in compliance with international security export control. If you intend to export any of these items, please consult JEOL. Procedures are required to obtain the export license from Japan’s government.

TRADEMARK

- Windows is a trademark of Microsoft Corporation.
- All other company and product names are trademarks or registered trademarks of their respective companies.

MANUFACTURER

JEOL Ltd. 1-2, Musashino 3-chome, Akishima, Tokyo 196-8558 Japan
Telephone: 81-42-543-1111 Facsimile: 81-42-546-3353 URL: http://www.jeol.co.jp

Note: For servicing and inquiries, please contact your JEOL service office.

SERVICE PROVIDER

JEOL DATUM Ltd. 1-2, Musashino 3-chome, Akishima, Tokyo 196-8558 Japan
Telephone: 81-42-526-5077 Facsimile: 81-42-526-5079

Contents

1. Precautions before Use

Please read this instruction manual thoroughly before using this product, then operate the product with a good understanding of the correct operating procedures.

Regarding cautions on safety, in particular, have a right understanding of the contents and absolutely bear them in mind. Otherwise, injury or death may be caused in the worst case.

Keep this instruction manual in an easy-to-access place so that the operator who practically operates the product actually may refer to it whenever necessary.

2. General Precautions

These are general precautions for using this product without causing any malfunction. Be sure to observe them. The product is checked for normal operations before it is delivered. However, it may cause an abnormal operation due to initial defect, aging phenomena, or other reasons. To prevent an unexpected accident, you are requested to incorporate a multiple safety means in your system or the product in consideration of a probable chain reaction or influence of a defective operation of our product.

2. 1 Precautions on Safety

The precautions described in this instruction manual are divided into “DANGER” and “WARNING”, “CAUTION” as shown below.

DANGER

An imminently hazardous situation which, if not avoided, will result in death or serious injury .

WARNING

This indicates the existence of a high hazard which, if the product is incorrectly operated, may cause damage to the product, resulting in a critical accident such as death or serious bodily injury.

CAUTION

This indicates the existence of a hazard which, if the product is incorrectly operated, may cause damage to the product or bodily injury. In items indicated as “CAUTION”, a critical accident may be caused depending on the situation.

⚠ **WARNING**

- Before inspecting, repairing or cleaning the plasma source, make sure that the power supply to this equipment is shut off.

⚠ **CAUTION**

- Check if the product delivered from us is identical with the specifications.

- When venting the chamber of the equipment, perform evacuation for 10 minutes or more beforehand, immediately after stopping its operation, and then carry out venting.

- Cool the equipment with cooling water for 10 minutes or more immediately after stopping its operation.

- When the surrounding temperature exceeds 80°C even if the equipment is not used, cool it with cooling water.

- Be sure to observe the flow rate and temperature of cooling water that are provided in the specifications. When there is a possibility that the temperature of the cooling water may exceed the specified temperature, take interlock for the temperature of cooling water. Be sure to take such interlock for cooling water based on the flow rate value. When an alarm of interlock for cooling water occurs, stop the equipment for 1 second or less.

3．General Description of Plasma Source System

3．1 Outline

3．1．1 Outline of plasma source system

This plasma source system consists of a built-in plasma source and a power supply for controlling the plasma source. The built-in plasma source is installed in the deposition process chamber to generate high-density plasma. When this plasma source system is applied to ion plating, it shows distinguished effectiveness for producing high-quality, highly functional films.

3．1．2 Features of built-in plasma source

1）High-density plasma ionizes vapor molecules and process gas molecules very efficiently.

2）The plasma beam is highly stable and easily controllable, allowing operation under low gas pressures (down to 2×10^{-2} Pa).

3）An electromagnetic coil or an external magnetic field can vary the shape of plasma beam because the plasma beam energy is sufficiently low.

4）Consumables like a filament can be exchanged or cleaned without removing the built-in plasma gun from the processing vacuum chamber. Its simple construction makes maintenance easy.

3．2 Specifications

3．2．1 Specification for plasma source system

1）Plasma Source (BS-80011BPG)

a．Maximum plasma output：6.08 kW （160 V, 38 A）

b．Working pressure ：1×10^{-2} to 1×10^{-1} Pa（Ar･O_2･N_2 gas）

c．Discharge gas ：8 to 20 mL/min（Argon）
Secondary pressure of gas cylinder
0.06 to 0.3 MPa（gauge）

d．Cooling water ：7 to 10 L/min（Water flow rate）
10 to 25°C（Temperature）
Pressure difference between inlet and outlet
0.25 to 0.35 MPa
Resistivity 5kΩ･cm or more
pH 6.5 to 8

e．Beam method ：Reflection beam
(Irradiation beam can be optionally available)

2）Accessories

ａ．Instruction manual ：1 set

ｂ．Maintenance jig ：1 set

ｃ．Maintenance tool ：Allen wrench set×１、Torque screwdriver set×１

ｄ．Consumables ：Filaments×２、Nozzles×２、Orifice×２
High-melting-point screws（M3×6）×４
High-melting-point screws（M3×8）×４
High-melting-point screws（M6×14）×２

３．２．２ Installation requirements

Requirements for installing the built-in plasma source is specified below.

1）Dimensions and weight (these might be modified due to improvement.)

ａ．Built-in plasma source
233 (dia.)mm×250 (L)mm×420.5 (H) mm (horizontal type)
Weight About 23 kg

2）Cooling water ：7 to 10 L/min(Flow rate)
10 to 25 °C (Temperature)
Pressure difference between inlet and outlet
0.25 to 0.35 MPa
Resistivity 5kΩ･cm or more
pH 6.5 to 8

3）Discharge gas : Argon gas purity 99.99% or higher
Secondary pressure of gas cylinder
0.06 to 0.3 MPa（gauge）

⚠ **CAUTION**

When you use the cooling water and discharge gas, be sure to satisfy their specifications before use. Especially, if the quality of the cooling water is low and you use it, the clogging or corrosion of the pipes might occur, causing problems in the equipment.

☆Recommended specifications for the cooling water

When you use the circulating water as the cooling water, the deterioration of the water quality might cause problems in the equipment. Periodically inspect the water quality, and if the quality does not satisfy its specifications, replace the circulating water as soon as possible for improving the water quality.

We recommend that when the quality of the water satisfies not only the above-mentioned specifications but also the following specifications, the safety of the equipment can be further secured even when problems in the equipment occur due to the low water quality.

The followings are the recommended specifications.

①Hardness: 100 mg$CaCo_3$/L or less

②Evaporation residue: 250 mg/L or less

③Chlorine ion: 50 mg/L or less

④Iron ion: 1 mg/L or less

⑤Sulfide ion: 50 mgSO_4^{2-}/L or less

⑥Ion silica: 30 mgSiO_2/L or less

3．3 Operating Principle of Plasma Source System

3．3．1 Operating principle of built-in plasma source system

The following are the explanations of the plasma source system. First, the argon plasma is generated inside the plasma source by the direct-current discharge of thermoelectrons emitted from the tungsten filament. The electrons in the plasma are accelerated by the electric field generated by the extracting electrode (anode) and introduced into the vacuum chamber. These electrons irradiate evaporated particles and the introduced argon gas inside the vacuum chamber, efficiently exciting and ionizing them. At the maximum power output rating, the discharge voltage and current are 160 V and 38 A.

Introducing the electron beam into the vacuum chamber diffuses the plasma widely inside the chamber and thereby high-density plasma is generated over the chamber interior. In addition, it is possible to select the irradiation-beam method or reflection-beam method by changing resistors A and B, which are connected between the chamber walls and extracting electrode.

3．3．2 Beam methods

By selecting appropriate beam methods, the advantageous effect of this plasma source is demonstrated to the maximum extent. The two beam methods have the following features.

1）Irradiation-beam method

In this method, electrons flow into grounded surfaces of the vacuum chamber walls. It can achieve highly efficient ionization. This method is useful for ion-plating substrates with metallic films because it can continue to provide stable discharge while maintaining the conductivity of the grounded surfaces of the chamber walls.

2）Reflection-beam method

The reflected electrons are not only introduced into the vacuum chamber, but also returned to the electrode. During this process, the extracting electrode heats due to the current that flows to it, and this heat cleans its surface. This process can maintain the conductivity of the extracting electrode and stable discharge even in an environment where the grounded surfaces of the vacuum chamber walls are covered with insulating materials. Thus, this method expands the applications of ion plating.

Fig. 3-1. Schematic diagram of built-in plasma source system

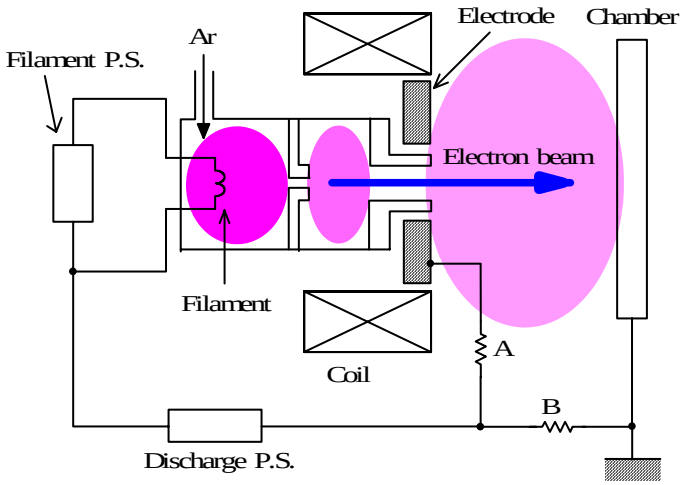
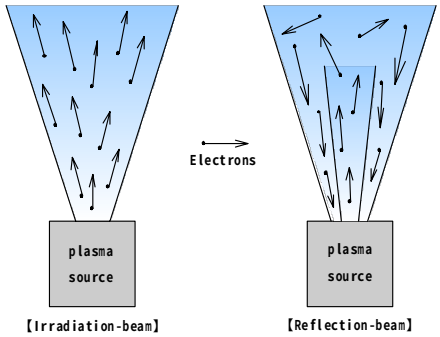


Fig. 3-2. Schematic diagram of the irradiation-beam method and reflection-beam method



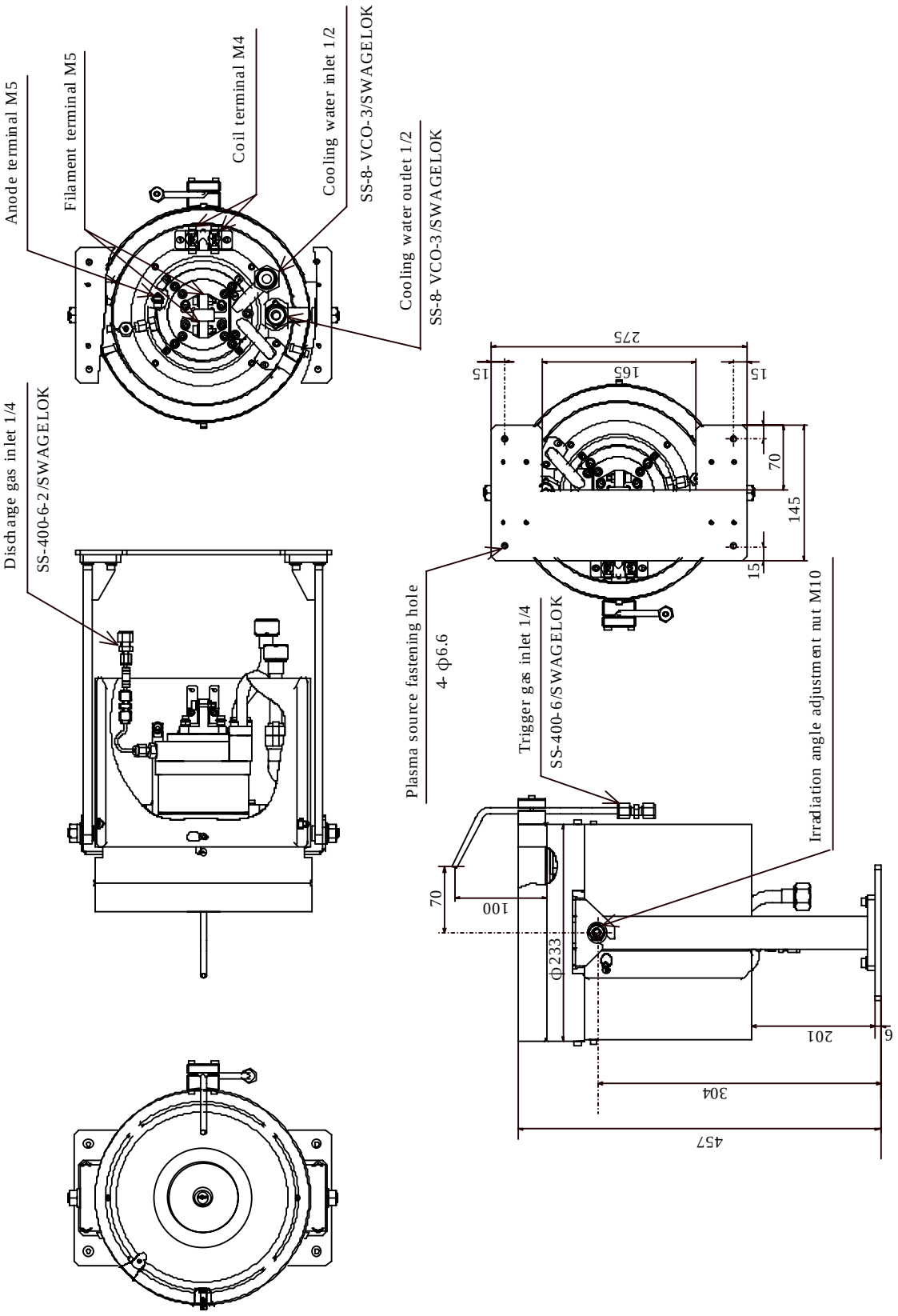
■Supplement

This equipment is designed based on the reflection-beam configuration. If you want to use the irradiation-beam configuration, which is optionally available, you need to add components to the built-in plasma source/plasma source control power supply, and changing the circuit constant for the equipment.

3．4 Configuration

We show the External view of Plasma Source (BS-80011BPG) in Fig. 3-3

Fig.3-3　External view of Plasma Source（BS-80011BPG）



4. Installing and Connecting

4. 1 Installing and Connecting the Plasma Source

4. 1. 1 Preparations for installing the plasma source

The parts shown in Table 4-1 are required for installing the built-in plasma source. Prepare these parts in advance.

Table 4-1

List of parts to be prepared	Specification and standard
①Filament current feedthrough	Withstand voltage 500 V, acceptable current 100 A or more, 2 pieces
②Anode current feedthrough	Withstand voltage 500 V, acceptable current 100 A or more, 1 piece
③Coil current feedthrough	Withstand voltage 500 V, acceptable current 100 A or more, 2 pieces
④Cooling water feedthrough	1/2 type (1/2 inch) , 2 pieces ※Note 1
⑤Discharge gas feedthrough	Withstand voltage 500 V, 1/4 type (1/4 inch) , 1 piece ※Note 1
⑥Cooling water flow meter	A flow rate of 7 L/min or more is detected. A-contact signal output is required.
⑦Cooling water pipe (atmospheric side)	1/2 type (1/2 inch) or more ※Note 2
⑧Cooling water pipe (vacuum side)	Stn. Stl. pipe and pipe joint of 1/2 type (1/2 inch) 1/2 VCO joint ※Note 1
⑨Discharge gas pipe (atmospheric side)	Teflon(or nylon) pipe and pipe joint of 1/4 type (1/4 inch) ※Note 3
⑩Discharge gas pipe (vacuum side)	Stn. Stl. pipe and pipe joint of 1/4 type (1/4 inch) ※Note 1
⑪Lead wire in a vacuum for filament	Acceptable current 100 A or more, Copper wire or Nickel wire , 2 pieces
⑫Lead wire in a vacuum for anode	Acceptable current 100 A or more, Copper wire or Nickel wire , 1 piece
⑬Lead wire in a vacuum for coil	Acceptable current 60 A or more, Copper wire or Nickel wire , 2 pieces
⑭Cover of Lead wire and pipe in a vacuum	※Note 4
⑮Plasma source trestle	※Note 5
⑯Discharge gas cylinder and gas cylinder regulator	Ar gas (high-purity gas 99.99% or more) Secondary pressure 0.06～0.3 MPa
⑰Water feed/discharge ball valve for cooling water	Pressure difference between inlet and outlet 0.25 to 0.35 MPa. Water temperature 10 to 25°C. Inlet pressure 0.5MPa or less.

※Note 1：Use Stn. Stl. (stainless steel) for the pipe material that is used in vacuum.
※Note 2：Even when cooling water has enough differential pressure, if the pipe is too narrow (inside diameter) or too long, cooling water may not meet the specifications due to insufficient conductance of the pipe. Use a cooling-water pipe with an adequate diameter (inside diameter).
※Note 3：Use a material that can keep the inside of the pipe in a vacuum (with the smallest possible leak amount) for the pipe material and pipe joint that are used on the atmospheric side.
※Note 4：Cover the wires for the plasma source and the discharge gas piping section to keep the plasma from entering them.
※Note 5：A base to fasten the plasma source is required. If tapped holes are provided on the floor surface of the vacuum equipment for fastening the plasma source, the trestle is not required.

4．1．2 Procedure for installing the plasma source

The procedure for installing the built-in plasma source is described below with an assumption that the source is mounted on the vacuum equipment.

1）Installing the built-in plasma source

Install the plasma source away from the evacuation system, for example, the chamber door side. The reason for this is the following: Since plasma is more stabilized for higher pressure, install the plasma source away from the evacuation system where the pressure is considered to be relatively high, so that the plasma beam irradiates toward the direction of the substrate (upward). At this time, be sure to fasten the plasma source. Provide a base to fasten the plasma source as necessary.

In addition, the plasma source generates a magnetic field. So, if the equipment that is affected by the generation of the magnetic field is installed within the same vacuum (equipment), separating the plasma source from the equipment or shielding the magnetic field may be required. If an electron beam evaporation gun is placed within the same vacuum, separate the center of the crucible and the filament of the electron gun from the outer circumference of the plasma source 300 mm or more. If the distance between the plasma source and the electron beam evaporation gun is small, the electron beam trajectories of both the plasma source and the electron beam evaporation gun might deviate due to the influences from them, caution is needed.

Regarding the layout of the plasma source, the optimum position must be determined according to the use and purpose. For details, please consult with JEOL Ltd.

2）Attaching the feedthroughs for the plasma source

Attach the dedicated feedthroughs (flange with inlet terminals) for the plasma source. Place the feedthroughs as near the plasma source as possible. For the specifications of the feedthroughs, refer to Table 4-1 to provide them.

⚠ WARNING

For the feedthroughs to which a voltage is applied, shield them with an anti-electric cover on the atmospheric side.

3）Piping work inside a vacuum

Connect the discharge gas pipe joint of the plasma source (mentioned in 1) and the cooling water pipe joint to the feedthroughs (mentioned in 2) by pipe. Since the discharge gas pipe is used by electrically floating, make a sufficient space so that the distance between the feedthroughs (mentioned in 2) and the plasma source (mentioned in 1) is 10 mm or more, in order that they do not contact other vacuum materials.

In addition, in piping (discharge gas pipe and cooling water pipe) and connecting the plasma source (mentioned in 1), take into consideration that mechanical strength is not applied to the connecting pipe joint on the plasma source side. Especially, for connecting the cooling water pipe joint for the plasma source to the feedthroughs for the cooling water, we recommend that you use a Stn. Stl. pipe. For the specifications of the pipes inside a vacuum, refer to Table 4-1 to provide them.

⚠ CAUTION

Take care not to apply excessive force such as torsion to the cooling water pipe joint.

⚠ CAUTION

Keep a distance of 10 mm or more between the discharge gas pipe and the lead wire or cooling water pipe.

4）Wiring inside a vacuum

Connect each feedthrough electrode terminal (filament terminal, anode electrode terminal, coil terminal) of the plasma source (mentioned in 1) to the feedthrough by a lead wire. We recommend you to use a lead wire with a bead insulator so that this lead wire does not contact other lead wires or pipes. For the specifications of the wiring parts inside a vacuum, refer to Table 4-1 to provide them.

CAUTION

When you use a lead wire without insulating cover or with a bead insulator, keep a distance of 10 mm or more between each lead wire and another lead wire, cooling water pipe, or discharge gas pipe not to contact each other.

5) Attaching a lead wire in a vacuum and pipe cover

Cover the wires for the plasma gun electrically floating against the grounding and the discharge gas piping section to prevent the plasma from entering them and from inducing abnormal discharge. By referring to a high-voltage cover for the electron beam evaporation gun, provide a cover with a little gap (10 mm or less). For details, consult with JEOL Ltd.

CAUTION

Keep a distance 10 mm or more between the cover and the lead wire or discharge gas pipe. You may use aluminum foil for the cover. However, the aluminum foil may be deformed and make contact with the lead wire or discharge gas pipe. Take care to avoid making contact.

6) Gas introduction piping for the anode section in the plasma source

A mechanism that introduces gas into the anode section is provided as a standard configuration for the plasma source. Gas introduction into the anode section enables the pressure in the anode section to vary and to stabilize the plasma operation and to control the plasma output. Sometimes, it is not necessary to introduce gas into the anode section depending on the evacuation performance of the vacuum equipment or the operating conditions of the plasma source. In this case, remove the gas-introduction piping parts for the anode section. When you introduce gas into the anode section, flow the gas that is introduced from the pipes in the anode section so that the gas passes through the center axis of the plasma source of the plasma source toward the evacuation system. If the plasma beam hits the edge section of the gas-introduction port and the edge section appears to be red, pull back the gas-introduction port to the radius.

In order to introduce gas into the anode section, it is necessary to provide the mass-flow controller, feedthroughs and piping parts inside and outside a vacuum.

If oxygen gas is introduced into the anode section, the wastage of the plasma-source electrode parts (carbon materials) due to oxidization or the deterioration of conductivity might occur.

Use oxygen gas with an introduction volume up to 50mL/min. When you switch the plasma beam from ON to OFF, stop the gas introduction into the anode section as soon as possible within 3 seconds). If not, the anode section might be oxidized, and this cause the instability of the plasma beam during the next ON, or decrease the plasma output.

⚠ **CAUTION**

When you introduce oxygen gas into the anode section, be careful on the oxygen gas volume and the ON/OFF timing of the introduction of oxygen gas.

7） Protective plate

If the vapor from the crucible might directly flow to the anode surface, it is necessary to provide the protective plate between the crucible and the anode of the plasma source. For details, consult with JEOL Ltd.

8） Piping work for discharge gas pipe on the atmospheric side

Argon (Ar) gas for the plasma source is introduced by the mass flow controller unit attached to the plasma source control power supply. Since the discharge gas feedthroughs (mentioned in 2) is electrically floated, when you carry out piping work for the atmospheric side, use a non-metallic pipe or insulate the feedthrough section, and be careful not to short-circuit the discharge gas feedthroughs with the grounding terminal. Also, provide Ar gas with a purity more than 99.99%, and select an appropriate pipe and a method of connecting pipe so that a vacuum is kept from the gas container regulator to the discharge gas feedthroughs. If the purity of the gas that is introduced into the plasma source is low, the wastage of the plasma-source electrode parts (tungsten filament, carbon materials) or the deterioration of conductivity, or the decrease in plasma output due to a reduced thermionic emission might occur.

⚠ **CAUTION**

When you use the discharge gas, be sure to satisfy its specifications before use. If the purity of the discharge gas is low, this badly affects the stable operation of the plasma source and the lifetime of the parts.

---

9) Piping work for cooling water pipe on the atmospheric side

Since the plasma gun is normally used with its inside temperature of 1000℃ to 2300℃, it is cooled by the cooling water. Be sure to obey the specifications of the volume of the cooling water.

Use a cooling water pipe with an inner diameter of at least 10 mm. If the pipe is too long, there is a vertical interval in the pipe, or there is an electromagnetic valve in the pipe, even when the inner diameter of the pipe is large, the specified volume of water might not flow.

Also, if there is a concern about the emergence of scale inside the pipe due to the quality of the cooling water, place a filter on the piping route of the cooling water. Furthermore, if the cooling water does not satisfy the specifications, there is a possibility that corrosion occurs on the piping route of the plasma source, so consult with JEOL Ltd. before you start to use the plasma source.

In addition, attach the cooling water flow meter on the piping route of the cooling water so that you can always monitor the flow rate of the cooling water regardless of the plasma source is used or not. Select an appropriate flow meter that can precisely measure the cooling water flow rate. Also, adjust the interlock signals so that the operation of the plasma source is stopped within one second if the cooling water flow rate does not satisfy the specification. Set the interlock value for the cooling water flow meter to 6.8 L/min.

CAUTION

When you use the cooling water and discharge gas, be sure to satisfy their specifications before use. Especially, if the quality of the cooling water is low and you use it, the clogging or corrosion of the pipes might occur, causing problems in the equipment.

---

10) Wiring work on the atmospheric side

Make a cable connection for each feedthrough on the atmospheric side with the plasma source control power supply using a cable attached to the plasma source control power supply. For the connection method, refer to the instruction manual provided with the plasma source control power supply.

5. Maintenance and Inspection

5. 1 Precautions on Operations

Usually, periodic maintenance and inspection is required to operate the equipment in the best condition for a long time. If any failure or defect occurs, make efforts at repairing it as soon as possible.

⚠ WARNING

Before starting inspection, be sure to check that the power supply to the equipment is shut off. Otherwise, an electric shock or injury may be caused.

⚠ CAUTION

Put on gloves when handling the plasma source.

---

5. 2 Routine Maintenance and Inspection

Before operating the plasma source, execute the check items mentioned in Table 5-1 and correct defective portions.

Table 5-1

Check item	Contents of check
①Cooling water flow rate	Check if the cooling water flow rate is 7 to 10L/min.
②Cooling water temperature	Check if the cooling water temperature is 10 to 25°C.
③Residual quantity of discharge gas in the cylinder	Check the residual quantity of gas.
④Interlock operation	Check if the interlock is normally operated with cooling water and vacuum pressure.
⑤Contamination on the anode surface	Refer to Section 5.4.1
⑥Wear of the anode	Refer to Section 5.4.1
⑦Wear of the nozzle	Refer to Section 5.4.1
⑧Lead wire and discharge gas pipe status	Check if the lead wires connected in the vacuum chamber are not slack or if the leads wires and discharge gas pipe are not short-circuited with another lead wire or vacuum section material.

Check item	Contents of check
⑨Fallen material near the anode	Check if there is not any fallen material or powdery material such as a deposited material near the anode.
⑩Life of the filament	Check the operating time of the filament.

5．3 Periodical Maintenance and Inspection

In addition to routine maintenance and inspection, execute the check items mentioned in Table 5-2 and correct defective portions.

Table 5-2

Check item	Contents of check	Check interval
①Wear of orifice part	Refer to Section 5.4.2	20 hours
②Wear of consumables in the discharge section	Refer to Section 5.4.2	100 hours
③Contamination of the filament section	Refer to Section 5.4.3	At filament replacement
④Fastening status of the filament holder	Refer to Section 5.4.3	At filament replacement
⑤Contamination of the filament holder	Refer to Section 5.4.3	At filament replacement
⑥Status of holder insulator	Refer to Section 5.4.3	At filament replacement
⑦Status of the high melting-point screws for the filament section	Refer to Section 5.4.3	At filament replacement
⑧Disassembly and cleaning of the plasma source	Refer to Section 5.4.4	1 month
⑨Looseness of the filament terminal / coil terminal	Refer to Section 5.4.4	1 month
⑩Status of the electrical insulation performance between electrode terminal and parts	Refer to Section 5.4.4	1 month
⑪Deterioration of O-rings	Refer to Section 5.4	1 month
⑫Status of insulators	Refer to Section 5.4	1 month
⑬Status of bolts	Refer to Section 5.4	1 month
⑭Status of taps	Refer to Section 5.4	1 month
⑮Status of each pipe joint section	Refer to Section 5.4	1 month
⑯Status of each cooling water pipe	Refer to Section 5.4.	1 month

5．4 Maintenance and Inspection for the Plasma Source

5．4．1 Maintenance for the anode section

As the surface of the anode becomes contaminated, plasma beams become unstable and discharge may be stopped. Each time the vacuum chamber is put in the atmospheric air, check the anode surface for contamination and conductivity and perform cleaning as required. The anode structure varies depending on the beam type (reflection beam or irradiation beam). In the following, how to maintain the anode section of the reflection beam type will be described. The irradiation beam type is available as an option.

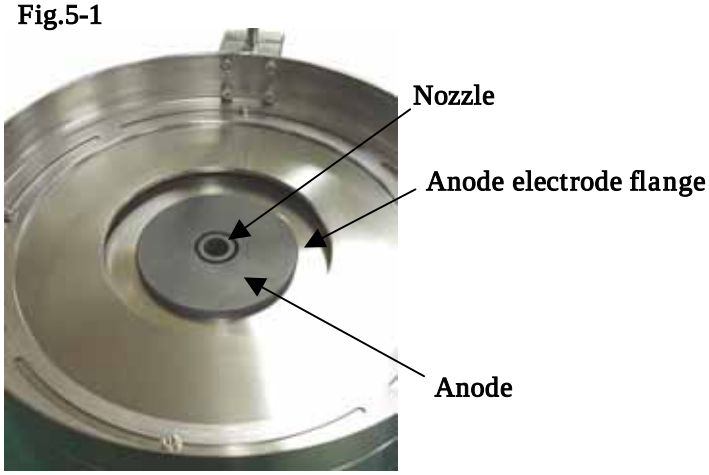
⚠ CAUTION

Make sure that the plasma source has been cooled enough.

⚠ CAUTION

When a torque value is specified, use a torque wrench.

Fig.5-1



1）Grasp the anode with a hand. Pull it upward and remove the anode from the anode electrode flange.

2）Check if the thickness of the anode disc section is 2 mm or more (5 mm in an unused status). If the thickness is less than 2 mm, replace the anode with a new one.

3）Check if the diameter of the anode bore is 23 mm or less (21 mm in an unused status). If the diameter is more than 23 mm, replace it with a new one.

Fig.5-2

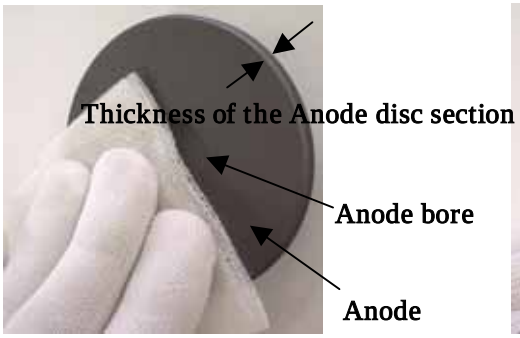
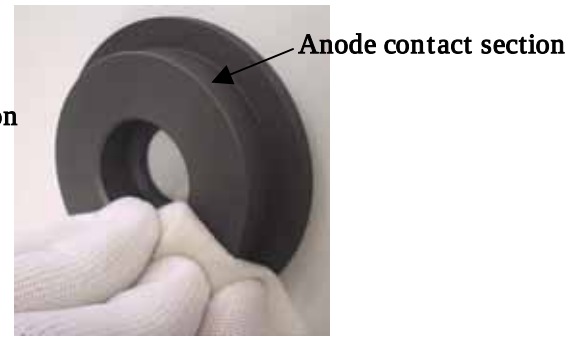
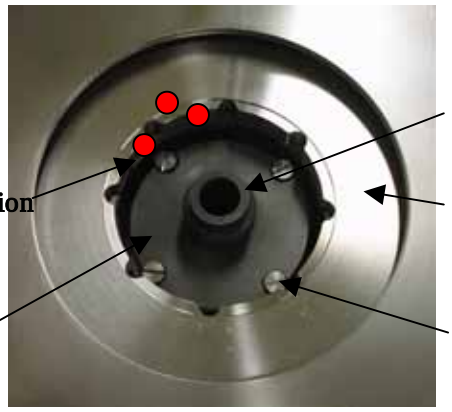


Fig.5-3



4) Measure the electric resistance of the anode surface with a tester and check if the resistance is 0.5Ω or less (standard resistance value). If the resistance value is more than the standard value or the contamination on the anode surface or the anode contact section in Fig.5-3 is distinctive, clean the contaminated portion. For cleaning, use BEMCOT／M-3, M-1 made by Asahi Kasei Corporation or equivalent, or use a brush with end-rounded bristles. If contaminants remain, carry out cleaning by using Scotch-Brite／No.7447 made by Sumitomo 3M or equivalent. Do not use alcohol for cleaning.

Fig.5-4



5) Measure the electric resistance of the surface of the anode insertion section with a tester by referring to a point indicated in Fig.5-4 and check if the resistance is 0.5 Ω or less (standard resistance value). If the resistance value is more than the standard value or the contamination on the surface of the anode insertion section is distinctive, clean this section. For cleaning, use Scotch-Brite／No.7447 made by Sumitomo 3M or equivalent. For finishing, wipe out contaminants by immersing alcohol on paper waste or an industrial wiper.

6) Turn the nozzle counterclockwise and remove it from the pipe.

7）Check if the head of the nozzle section is above 5 mm (7 mm in an unused status). When the height is below 5 mm, replace the nozzle with a new one.

Fig.5-5

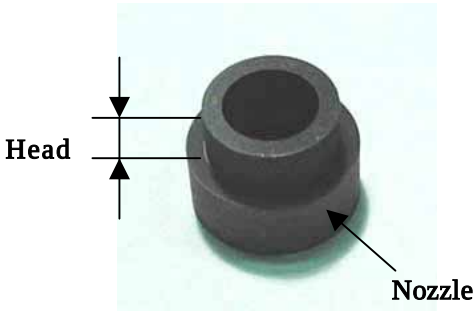


Fig.5-6

8）If particle contaminants are deposited on the nozzle surface, by referring to Fig.5-6, clean the surface by using BEMCOT／M-3, M-1 made by Asahi Kasei Corporation or equivalent, or by using a brush with end-rounded bristles. Do not use alcohol for cleaning.

9）Attach the new nozzle on the pipe. Put the nozzle on the pipe and turn it clockwise until it is stopped.

10）Attach the anode on the anode electrode flange. Grasp the anode disc section with a hand and insert it in the anode electrode flange.

11）Check if the nozzle is positioned at the center against the anode bore. Visually check the clearance between the anode and the nozzle as shown in Fig.5-7. If the nozzle attaching position is shifted, loosen the high melting point screws for fastening the pipe shown in Fig.5-4 and adjust the nozzle attaching position. After completing the adjustment, tighten the high melting point screws for fastening the pipe with a torque value of 5N･cm.

Fig.5-7

⚠ CAUTION

For fastening the pipe, use a torque wrench. If the screws are tightened firmly without using the torque wrench, the pipe or ring might be damaged.

5．4．2 Maintenance for the discharge section

The discharge section of the plasma source is a plasma generating area using discharge gas. The component parts of the discharge section are put in a high-temperature environment and repeatedly expanded and shrunk thermally, so that they are deteriorated and worn away by plasma ion impacts. Check the discharge section status periodically. The contents of inspection and the assembling procedure are described below.

⚠ CAUTION

Make sure that the plasma source has been cooled enough.

⚠ CAUTION

When a torque value is specified, use a torque wrench.

1）Remove the anode parts by referring to Section 5.4.1. For the nozzle parts, remove them according to necessities.
2）Remove the two of the four high melting point screws that fasten the pipe on the ring (Fig. 5-4). The two screws to be removed are located on two diagonal lines.
3）By referring to Fig.5-8, tighten the two bolt-shaped jigC on the plasma source instead of the two removed high melting point screws.
4）Remove the rest of two high melting point screws that fasten the pipe, and remove the pipe from the plasma source.
5）Check if the diameter of the pipe bore is 14 mm or less (12 mm in an unused status). If the diameter is more than 14 mm, replace the pipe with a new one.
6）If particle contaminants are deposited on the pipe surface, clean the surface by using BEMCOT／M-3, M-1 made by Asahi Kasei Corporation or equivalent, or by using a brush with end-rounded bristles. If the contaminants remain on the surface, further carry out cleaning by using Scotch-Brite／No.7447 made by Sumitomo 3M or equivalent. Do not use alcohol for cleaning.

Fig.5-8

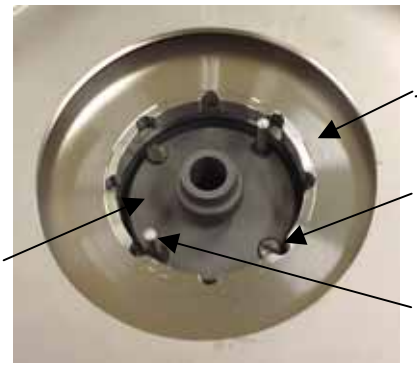


Fig.5-9

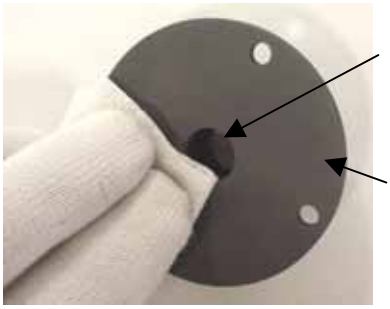


Fig.5-10

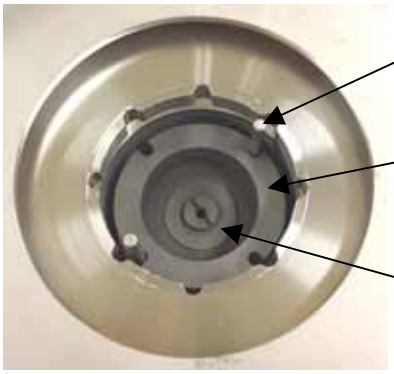


Fig.5-11

7）Turn the orifice counterclockwise and remove it from the ring. Using a bladed screwdriver facilitates this removing operation.

8）Check if the diameter of the orifice bore is 5 mm or less (4 mm in an unused status). If the diameter is more than 5 mm, replace the orifice with a new one.

9）If particle contaminants are deposited on the orifice surface, clean the surface by using BEMCOT／M-3, M-1 made by Asahi Kasei Corporation or equivalent, or by using a brush with end-rounded bristles. If the contaminants remain on the surface, further carry out cleaning by using Scotch-Brite／No.7447 made by Sumitomo 3M or equivalent. Do not use alcohol for cleaning.

10）Remove the ring (Fig. 5-12) and the spacer (Fig. 5-14).

Fig.5-12

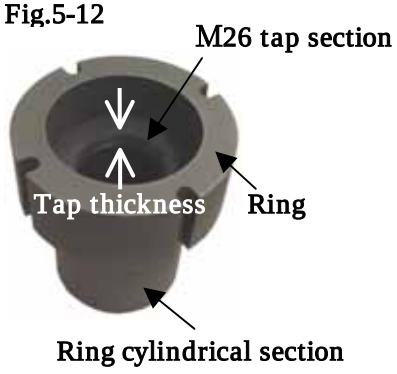
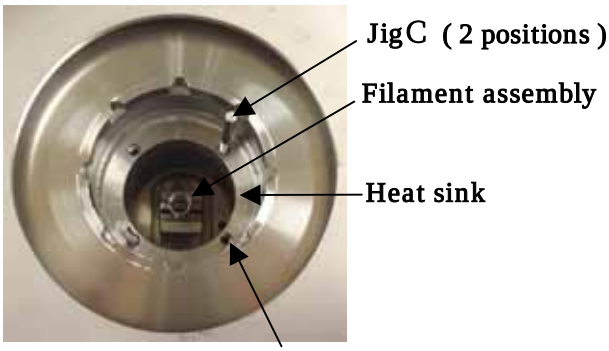


Fig.5-13



11) Check if the thickness of the M26 tap section of the ring is 6 mm or more (7 mm in an unused status) or if the inner diameter of the cylindrical section is 42 mm or less (40 mm in an unused status). If the thickness of the M26 tap section is 6 mm or less and the inner diameter of the cylindrical section is more than 42 mm, replace the ring with a new one.

12) If particle contaminants are deposited on the ring surface, clean the surface by using BEMCOT／M-3, M-1 made by Asahi Kasei Corporation or equivalent, or by using a brush with end-rounded bristles. If the contaminants remain on the surface, further carry out cleaning by using Scotch-Brite／No.7447 made by Sumitomo 3M or equivalent. Do not use alcohol for cleaning.

13) Place the spacer ring (Fig. 5-14) on the flat surface and check if deformation or distortion is present on the spacer. If deformation or distortion is found, replace the spacer with a new one.

⚠ CAUTION

The spacer is a part to prevent seizing between the ring and heat sink. During the use of the plasma source, the seizing might occur. In this case, do not forcibly remove the spacer and use it until the replacement time. If you forcibly remove the spacer, the spacer is deformed and it cannot be used. Using the deformed spacer cause instability of the plasma beam. Do not avoid the use of the deformed spacer.

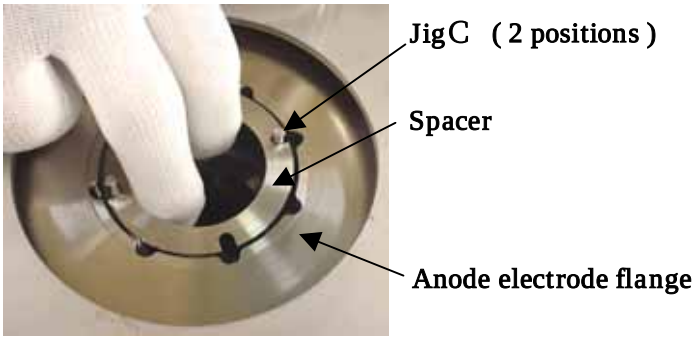
---

14) If membrane or particle contaminants remain inside walls of the heat sink, carry out cleaning by referring to Section 5.4.4, Dismantling, inspection and assembling of the plasma source.

15）Next, by reversing the operation in removing the pipe and ring parts from the heat sink, attach the pipe and ring parts on the plasma source. First, by referring to Fig. 5-13, tighten the two jigC on the tapped hole for fastening the ring so that the two jigC are faced to each other with respect to a diagonal line.

16）By referring to Fig. 5-14, first insert the spacer into the plasma gun.

Fig.5-14



17）Place the ring on the spacer by referring to Fig.5-10.

18）By reversing the operation in removing the orifice, attach the orifice to the ring. Place the orifice on the M26 tap section of the ring and turn the orifice clockwise until it is stopped. Using a bladed screwdriver facilitates this attaching operation.

19）Place the pipe on the ring by referring to Fig.5-8.

20）Attach the pipe, ring and spacer to the heat sink with the two high melting point screws (M4×30). Note that position adjustment of the anode and nozzle is carried out after the pipe, ring and spacer is attached to the heat sink, temporarily attach them by loosely fastening the high melting point screws. Then, remove the two jigC, and temporarily attach them to the heat sink with the two high melting point screws (M4 ×30).

21）Attach the anode and nozzle parts by referring to Section 5.4.1, Maintenance for the anode section.

22）Carry out position adjustment of the anode and nozzle by referring to Section 5.4.1, 11). When position adjustment is completed, attach the pipe, ring and spacer to the heat sink with the four high melting point screws (M4×30). Tighten them with a torque value of 5N･cm.

⚠ CAUTION

For fastening the pipe, use a torque wrench. If the screws are tightened firmly without using the torque wrench, the pipe or ring might be damaged. In addition, if the status of the high melting point screws used to fasten the pipe and ring or the status of the tap section is poor, replace the screws or perform tap processing. If the equipment is used in such a status, the screws might not be removable.

5．4．3 Maintenance for the filament section

In order to keep stable operation of the plasma source, periodical maintenance of the filament section is important. At each replacement work of the filament, inspect the status of the component parts of the filament section, and find and repair abnormal positions as soon as possible.

⚠ CAUTION

Make sure that the plasma source is cooled enough.

⚠ CAUTION

Use a torque wrench if a torque value is specified.

5．4．3．1 Installing and removing the filament assembly

For installing and removing the filament assembly, you can select two ways: installing and removing from the anode section or from the flange section.
Here, the procedure for installing and removing the filament assembly from the anode section is described below.

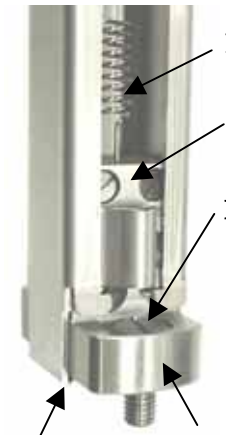
1）By referring to Section 5.4.1, Maintenance for the anode section and Section 5.4.2, Maintenance for the discharge section, remove the anode, nozzle, pipe, ring and orifice. If it is not necessary to remove the nozzle and orifice, you can keep them being attached on the pipe and ring respectively.

Fig.5-15

Filament replacement Jig

Fig.5-16

Fig.5-17

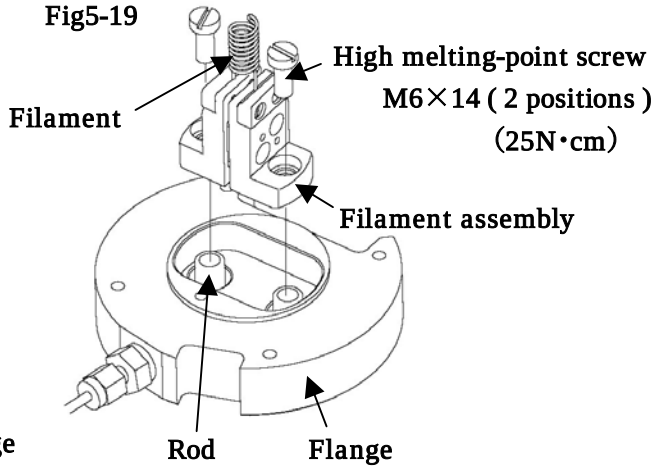


2）Loosen the two high melting point screws that fasten the filament assembly to the rod (in Fig. 5-17) until they spin free. At this time, do not remove the high melting point screws yet.

3）Next, by using the filament replacement jig shown in fig. 5-15 and by referring to Figs. 5-13, 5-16 and 5-17, insert the filament replacement jig into the filament assembly from the anode electrode flange side, and then grasp the filament assembly with the filament replacement jig. At this time, grasp the filament assembly so that the click on the head of the filament replacement jig contacts the lower surface of the holder surface of the filament assembly.

Fig5-18

Fig5-19



4）By referring to Fig.5-18, pull up the filament replacement jig while grasping the filament assembly and remove the filament assembly from the main body of the plasma source.

5）Place the filament assembly on the flat surface. If it is necessary to replace the filament, replace it by referring to Section 5.4.3.2, Replacing the filament.

6）Next, install the filament assembly on the main body of the plasma source. First, insert the two high melting point screws (M6×14) into the holder of the filament assembly by referring to Fig. 5-19.

7）By using the filament replacement jig and by referring to Fig.5-15, grasp the filament assembly with the filament replacement jig. At this time, grasp the filament assembly so that the click on the head of the filament replacement jig contacts the lower surface of the holder surface of the filament assembly.

8）By referring to Fig. 5-18, insert the filament assembly from the anode electrode flange side while grasping the filament assembly with the filament replacement jig, and then place the filament assembly on the two rods shown in Fig. 5-19, finally put the rods in the spot facing hole on the lower surface of the holder.

9）When the holder of the filament assembly is firmly set on the rods, install the filament assembly on the rods with the two high melting point screws (M6×14). Fasten the filament assembly with a torque value of 25 N-cm.

⚠ **CAUTION**

For fastening the filament assembly, use a torque wrench. If the high melting point screws are tightened firmly without using the torque wrench, the high melting point screws might be damaged. In addition, if the status of the high melting point screws used to fasten the filament assembly or the status of the tap section is poor, replace the screws or perform tap processing. If the equipment is used in such a status, the screws might not be removable.

5．4．3．2 Replacing the filament

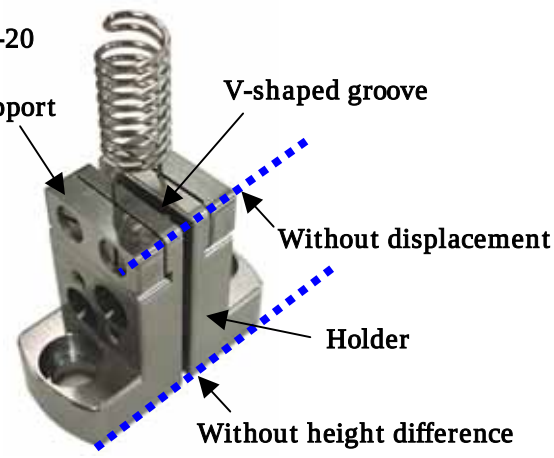
The procedure for replacing the filament is described below.

1）Place the filament assembly on the flat surface. By referring to Fig.5-20, check if there is no height difference between the lower surfaces of the both holders and also there is no displacement between the sides of the both holders. If you find abnormalities, take adequate measures as soon as possible by obeying Section 5.4.3.3, Maintenance for the filament assembly.

2）For removing the filament from the filament assembly, loosen the four high melting point screws of the support section, and then pull out the filament.

3）For installing the filament on the filament assembly, insert the filament vertically into the V-shaped groove until it is stopped, and then fasten the filament with four M3×6 high melting point screws by referring to Fig.5-21. Fasten the filament with a torque value of 25 N-cm.

Fig.5-20



Filament assembly

⚠ CAUTION

Make sure that the filament is put in the V-groove.

⚠ CAUTION

For fastening the filament, use a torque wrench. If the high melting point screws are tightened firmly without using the torque wrench, the high melting point screws might be damaged or seized on the holder or support.

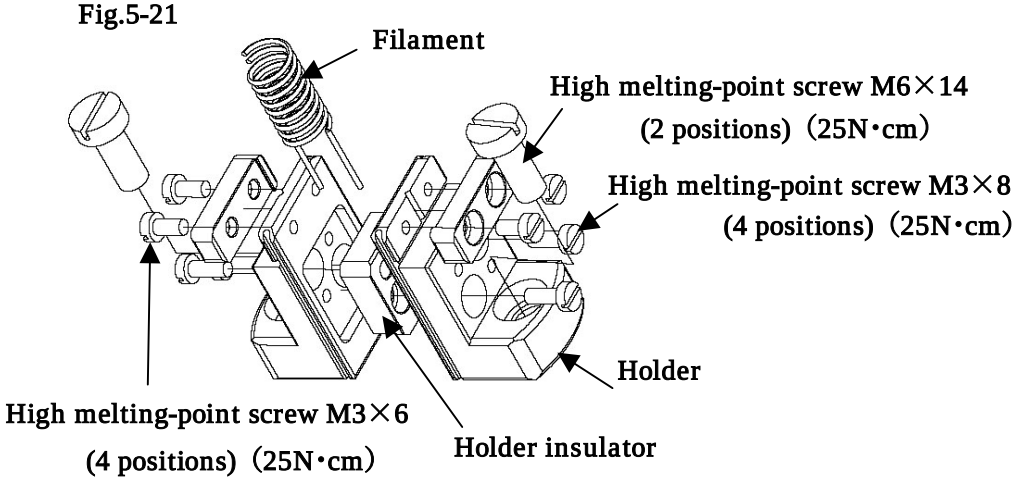
⚠ CAUTION

If the status of the bolts used to fasten the filament or the status of the tap section is poor, replace the bolts or perform tap processing. If the equipment is used in such a status, the bolts may not be removable.

5．4．3．3 Maintenance for the filament assembly

The procedure for the maintenance for the filament assembly is described below.

Fig.5-21



1）Place the filament assembly on the flat surface. By referring to Fig. 5-20, adjust the filament assembly so that there is no height difference between the lower surfaces of the both holders and also there is no displacement between the lateral sides of the both holders. Loosen the high melting point M3×8 screws (in Fig. 5-21) to adjust the displacement, and confirm that there is no displacement. Then fasten the both holders on the holder insulator with the four high melting point M3×8 screws. Fastening the both holders with a torque value of 25 N-cm.

⚠ CAUTION

For fastening the holders, use a torque wrench. If the high melting point screws are tightened firmly without using the torque wrench, the high melting point screws might be damaged.

⚠ CAUTION

If the status of the high melting point screws used to fasten the holders or the status of the tap section is poor, replace the screws or perform tap processing. If the equipment is used in such a status, the screws might not be removable.

2）Contact a tester to both of the holders without filament and measure the resistance value between the holders, and then check if the resistance value is 100 kΩ or less. If the resistance value is less than 100 kΩ, clean the insulator by glass shot until the resistance value becomes 100 kΩ or more.

⚠ CAUTION

When clean the insulator by glass shot, carry out it lightly. If you do it strongly, the insulator might be damaged.

3）If the holders and support section are contaminated or membranes are deposited on them, clean them.
For cleaning, use Scotch-Brite／No.7447 made by Sumitomo 3M or equivalent. For finishing, wipe out contaminants by immersing alcohol on paper waste or an industrial wiper.

4）Check if the high melting point M3×6 screws on the support section that are used to fasten the filament (in Fig.5-21) are loose or not. If they are loose, by referring to Section 5.4.3.2, Replacing the filament, fasten the high melting point screws with a torque value of 25 N-cm.

⚠ CAUTION

Replace the high melting point M3×6 screws frequently (every 200 hours). If you continue to use them for more than 200 hours , you might later be unable to remove them.

5．4．4 Disassembling, inspecting, and assembling the plasma source

When the plasma source has been used for a long time, various symptoms will appear. For example, the discharge section will be worn away, the O-rings will be deteriorated, and fastening screws for fastening each section will be loosen or deteriorated. Accordingly, perform disassembly, cleaning, and maintenance periodically for the plasma source.

⚠ CAUTION

Make sure that the plasma source has been cooled enough.

⚠ CAUTION

When a torque value is specified, use a torque wrench.

5．4．4．1 Disassembling the plasma source

The disassembling operations for the plasma source are described below. Take out the plasma source from the vacuum chamber and put it in a ready status for these operations.

Fig.5-22

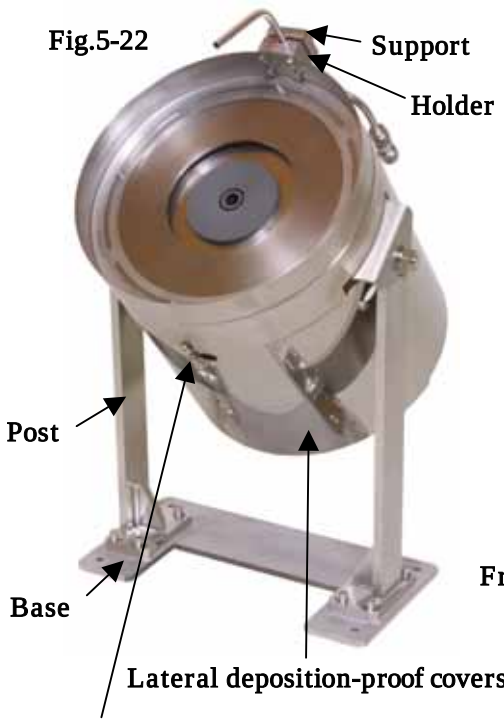
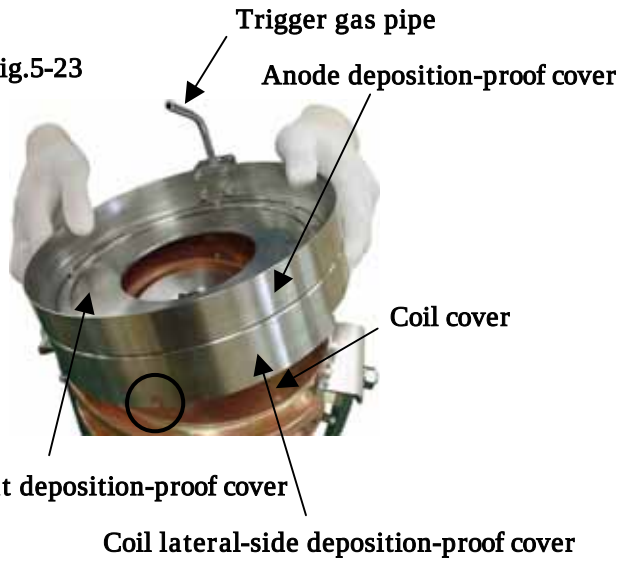


Fig.5-23



1）Loosen the Stn.Stl. bolts (2 positions) that fasten the coil lateral-side deposition-proof covers in Fig.5-22.

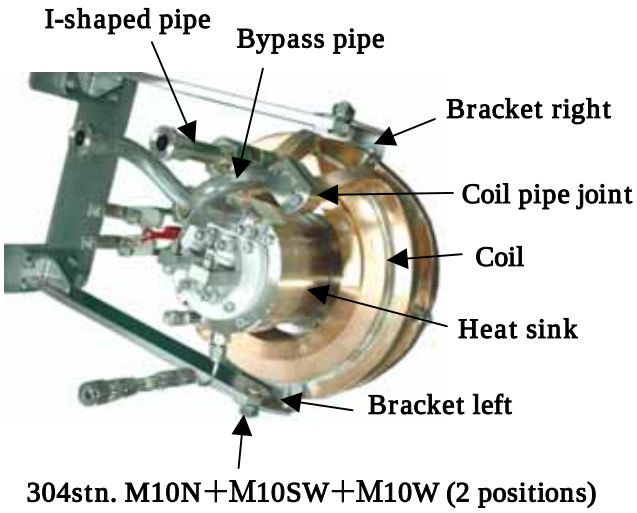
2）Remove the cover set (including the coil lateral-side deposition-proof covers, the front deposition-proof cover, the anode deposition-proof cover and the trigger gas pipe) while confirming the guide mark indicated by a circle in Fig.5-23. If it is not necessary to disassemble the cover set on the upper portion of the plasma source, keep it remaining.

3）Loosen the Stn.Stl. bolts (4 positions) that fasten the lateral-side deposition-proof covers in Fig.5-22 and remove the lateral-side deposition-proof covers (big and small).

4）Remove the anode and nozzle by refereeing to Section 5.4.1, Maintenance for the anode section.

5）By referring to Fig.5-24, place the plasma source on the flat surface so that the anode side faces downward. At this time, according to necessities, loosen the Stn.Stl. nuts (N) for the bracket section in Fig. 5-24 and remove the plasma source trestle.

Fig.5-24



⚠ CAUTION

Since the plasma source is heavy, when you move the plasma source, be carefully perform it.

6）Remove the three Stn.Stl. bolts that fasten the bypass pipe on the heat sink and the two Stn.Stl. bolts that fasten the bypass pipe on the coil pipe joint. Then, remove the bypass pipe. At this time, bypass pipe insulator, screw insulator, Stn.Stl. spring washers (SW) can also be removed. Do not remove the I-shape pipe except when it must be removed.

7）By referring to Fig.5-25, remove the four Stn.Stl. bolts and Stn.Stl. spring washers (SW) that fasten the stopper on the coil. Then ,pull out the stopper from the coil.

8）By referring to Fig. 5-25, hold the main body of the plasma source with a hand and pull it out straight upward from the coil. After pulling out it, place it on the jigA as shown in Fig. 5-26.

9）Turn the anode electrode terminal (in Fig. 5-26) counterclockwise and remove it from the anode electrode flange.

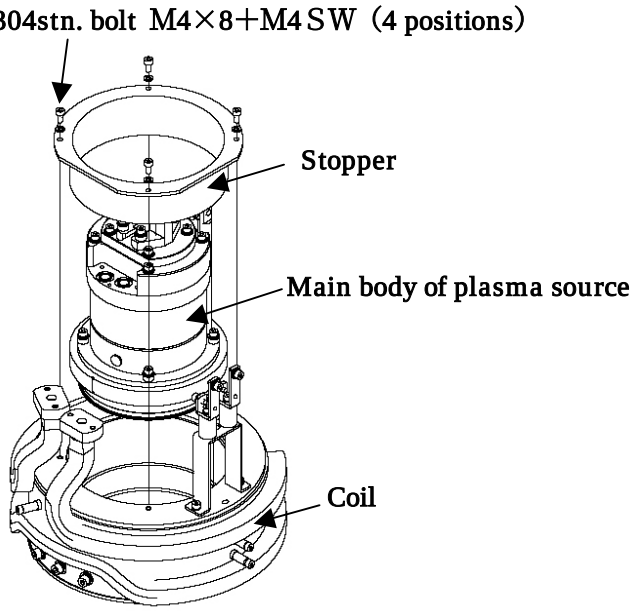


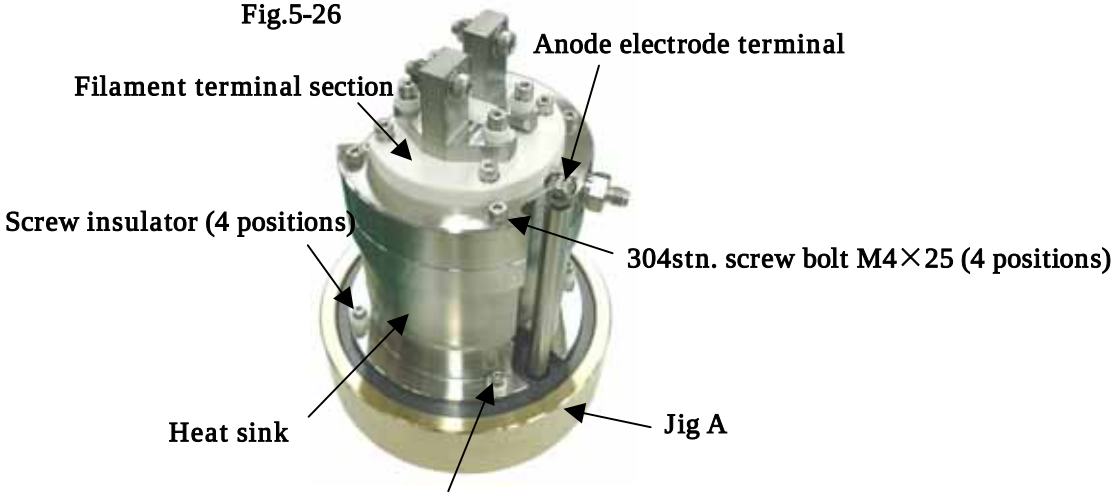
Fig.5-25

10）Remove the four Stn.Stl. bolts that fasten the heat sink (in Fig.5-26) on the anode electrode flange. At this time, the anode insulator, screw insulator, Stn.Stl. spring washers (SW) and Stn.Stl. washers (W) can also be removed.

11）Remove the four Stn.Stl. bolts that fasten the filament terminal section (in Fig. 5-26) on the heat sink. Then, remove the filament terminal section from the heat sink.

12）Remove the pipe and ring parts by referring to Section 5.4.2, Maintenance for the discharge section.

Fig.5-26



5．4．4．2 Inspecting the plasma source

Perform inspection about the check items shown in Table 5-3. Regarding the filament section, anode section, and discharge section, execute the contents of check described in Sub-section 5.4.1 to Sub-section 5.4.3. If any defect is found as a result of inspection, execute replacement of parts, cleaning, etc.

Table 5-3

Check item	Contents of check
①Status of insulators	Check all insulators for dirt or cracks on their surfaces, and deterioration in their electric insulation. ※Note 1
②Status of O-rings	Check all the O-rings to make sure they are elastic and have no dirt on their surfaces.
③Status of high-melting-point screws	Check all the high-melting-point screws to make sure they are not deformed, cracked or beyond the replacement time.
④Status of the tap sections	Check all the tap sections if deformation is present or unreasonable strength is generated for fastening the screw bolts. ※Note 2
⑤Contamination of component parts in the discharge section (parts exposed to plasma)	Check all the components in the discharge section to make sure they do not have any powder on them, and are not discolored. ※Note 3
⑥Status of Stn.Stl. bolts and SW(spring washers)	Check all the bolts for deformation and all the SWs for spring deterioration.
⑦Loosening of terminal section	Check the coil terminal, filament terminal and bracket for loosening.
⑧Status of the pipe joint weld section	Check all the pipe joints to make sure they are free of cracks, pinholes and leak in the welds
⑨Status of O-ring grooves	Check all the grooves for the O-rings to make sure they are free of dirt, and check the surfaces around the O-rings to make sure they are free of cracks.
⑩Contamination in the cooling water pipe	Check if there is not any fur in every pipe connecting section.

※Note 1：For checking the electric insulation performance, measure the resistance value at several points of the insulator surface with a tester and check if each single insulator has a resistance value of 100 kΩ or more.

※Note 2：Check the tap status by inserting a bolt in the tap section. If the tap status is poor, perform tap processing.

※Note3：For cleaning the carbon parts, use BEMCOT／M-3, M-1 made by Asahi Kasei Corporation or equivalent, or use a brush with end-rounded bristles. Do not use alcohol for cleaning. For cleaning the metal parts, use Scotch-Brite／No.7447 made by Sumitomo 3M or equivalent. For finishing, wipe out contaminants by immersing alcohol on paper waste or an industrial wiper.

5．4．4．3 Assembling the plasma source

The procedure for assembling the plasma source is described below. This procedure starts with the status subsequent to 5.4.4.1, Disassembling the plasma source. For assembling the filament section, anode section and discharge section, refer to Section 8.4.1 to 8.4.3.

Fig.5-27

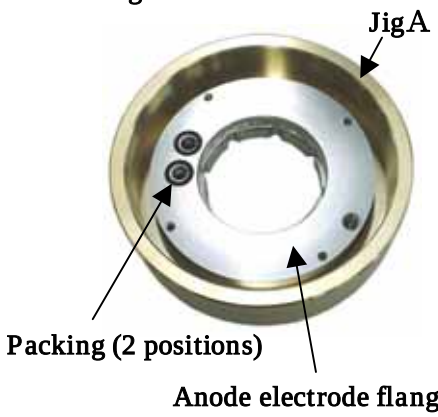
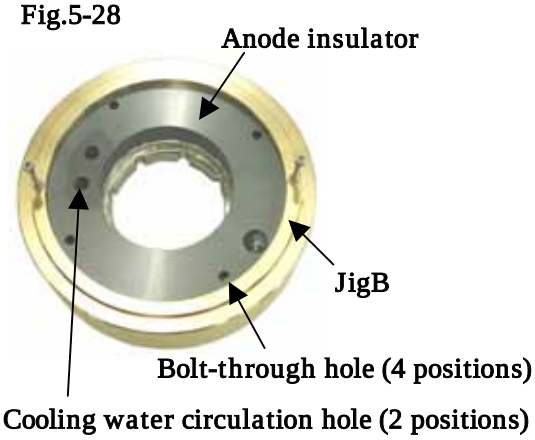


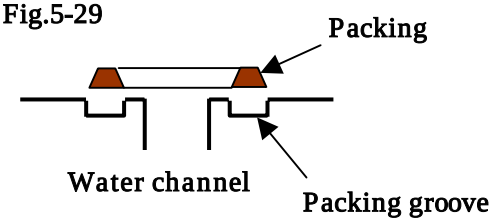
Fig.5-28



1）Set the anode electrode flange on the jigA shown in Fig.5-27. The jigA has a positioning guide that enables setting the anode electrode flange at the center of the jigA. Make sure that when the anode electrode flange is set on the jigA, the anode electrode is settled in the positioning guide.

2）Set the packing on the packing groove on the anode electrode flange shown in Fig.5-27. The packing should be set in a correct direction. As is shown in Fig. 5-29, the cross section of the packing is a trapezoid. Set the packing so that the longer base of the packing is faced toward the packing groove.

Fig.5-29



⚠ CAUTION

Be sure to set the packing on the anode electrode flange and be careful to set the packing so that it should be set in a correct direction.

---

3) Set the anode insulator on the jig A shown in Fig.5-28. At this time, the anode insulator should be adjusted accurately to the cooling water circulation hole positions of the anode electrode flange. Next, adjust the four bolt through-holes of the anode insulator accurately to the four tapped holes of the anode electrode flange.

4) Set the jigB on the anode insulator shown in Fig.5-28. Make sure the jigB is settled in the jigA.

5) Set the packing on the packing groove on the heat sink shown in Fig.5-30 and 5-31. The packing should be set in a correct direction. As is shown in Fig.5-29, the cross section of the packing is a trapezoid. Set the packing so that the longer base of the packing is faced toward the packing groove.

⚠ **CAUTION**

Be sure to set the packing on the heat sink and be careful to set the packing so that it should be set in a correct direction.

Fig.5-30

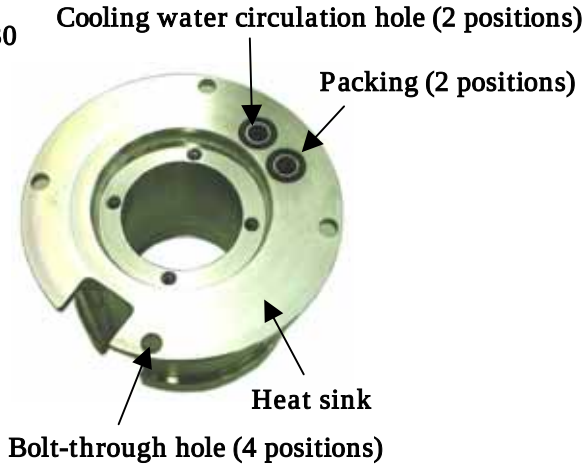


Fig.5-31

6) Place the heat sink on the anode insulator. At this time, adjust the position of the anode insulator to that of the cooling water circulation hole on the heat sink. Next, adjust the position of the anode insulator to those of the four bolt through-holes of the heat sink.

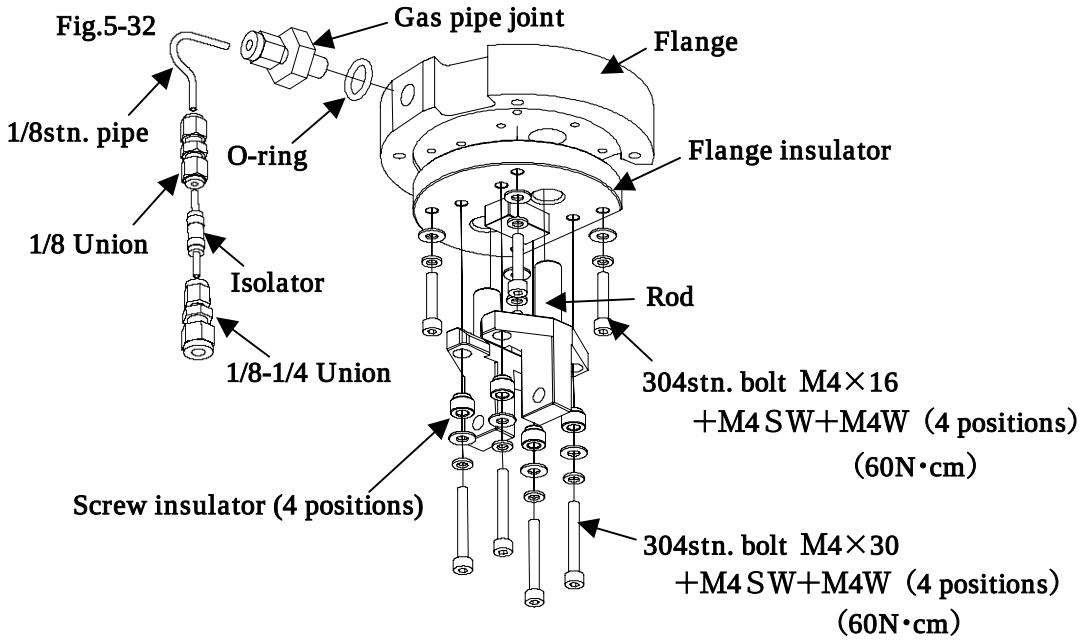
7) After positioning the heat sink, fasten the heat sink on the anode electrode flange with the four M4×30 Stn.Stl. bolts. At this time, set the Stn.Stl. M4 spring washers (SW), the Stn.Stl. M4 washers (W) and the screw insulator on the Stn.Stl. bolts.
Fasten the screws with a torque value of 60 N-cm.

⚠ CAUTION

For fastening the heat sink, use a torque wrench. If the bolts are tightened firmly without using the torque wrench, the screw insulators might be damaged.

8）Next, assemble the filament terminal section. Note that if you have not disassembled the filament terminal section in Section 5.4.4.1, Disassembling the plasma source, inspect the loosening status of the Stn.Stl. bolts and the electric insulation performance between rods (with filament removed) and the appearance of the flange insulator.

Fig.5-32



9）By referring to Fig.5-32, fasten the flange insulator on the flange with the four M4×16 Stn.Stl. bolts. At this time, set the Stn.Stl. M4 spring washers (SW) and the Stn.Stl. M4 washers (W) on the Stn.Stl. bolts. Fasten the screws with a torque value of 60 N-cm.

⚠ CAUTION

For fastening the flange insulator, use a torque wrench. If the bolts are tightened firmly without using the torque wrench, the flange insulators might be damaged.

１０）By referring to Fig.5-32, fasten the rod on the flange through the flange insulator with the four M4×30 Stn.Stl. bolts. At this time, set the Stn.Stl. M4 spring washers (SW), the Stn.Stl. M4 washers (W) and the screw insulator on the Stn.Stl. bolts. Fasten the screws with a torque value of 60 N-cm. Also, at this time, as is shown in Fig. 5-33, set the rod so that it contacts the lateral side of the convex section of the flange insulator with no gap between them.

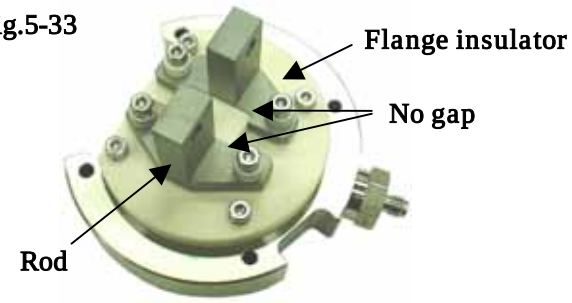
⚠ CAUTION

For fastening the rod, use a torque wrench. If the bolts are tightened firmly without using the torque wrench, the screw insulators might be damaged.

⚠ CAUTION

Be careful to make sure that there is no gap between the rod and the convex section of the flange insulator. If there is a gap, the filament assembly might not be installed.

Fig.5-33



１１）By referring to Fig.5-32, set the O-ring on the O-ring groove of the gas pipe joint and install the O-ring on the flange. The head of the gas pipe joint is constructed of screws. Install the O-ring with the same procedure as fastening the bolts. Make sure that there is no gap between the gas pipe joint and the flange.

⚠ CAUTION

Be sure to set the O-ring on the gas pipe joint.

---

12) By referring to Fig.5-26, place the filament terminal section on the heat sink and fasten the filament terminal section on the heat sink with the four M4×25 Stn.Stl. bolts.

13) By referring to Fig.5-26, install the anode electrode terminal on the anode electrode flange. The head of the anode electrode terminal is constructed of screws. Install the anode electrode terminal with the same procedure as fastening the bolts.

14) By referring to Fig.5-25, take out the main body of the plasma source from the jigA and jigB, and set it on the coil.

15) By referring to Fig.5-25, set the stopper on the coil. The stopper should be set in a correct direction. Set the stopper so that the notch cutting section of its outer circumference agrees with the positions of the coil terminal section and the cooling-water pipe joint section.

16) By referring to Fig.5-34, set the packing on the bypass pipe. The packing should be set in a correct direction. As is shown in Fig.5-29, the cross section of the packing is a trapezoid. Set the packing so that the longer base of the packing is faced toward the packing groove.

⚠ **CAUTION**

Be sure to set the packing on the heat sink and be careful to set the packing so that it should be set in a correct direction.

Fig.5-34

17) By referring to Fig.5-35, place the bypass pipe insulator on the heat sink and then, place the bypass pipe on the bypass pipe insulator and coil pipe joint. If the position of the bypass pipe insulator does not agree with that of the coil pipe joint, turn the main body of the plasma source clockwise and counterclockwise for adjusting the positions.

18) By referring to Fig.5-35, temporarily set the bypass pipe on the heat sink with the four M4×50 Stn.Stl. bolts. At this time, set the Stn.Stl. M4 spring washers (SW), the Stn.Stl. M4 washers (W) and the screw insulator on the Stn.Stl. bolts. Before this setting, loosen the Stn.Stl. bolts.

19) By referring to Fig.5-35, temporarily set the bypass pipe on the coil pipe joint with the two M4×18 Stn.Stl. bolts. At this time, set the Stn.Stl. M4 spring washers (SW) on the Stn.Stl. bolts. Before this setting, loosen the Stn.Stl. bolts.

20) Turn the main body of the plasma source for readjusting the positional relations among the bypass-pipe joint section, the bypass pipe insulator and the coil pipe joint. Then, fasten the bypass pipe on the heat sink and the coil pipe joint. Fasten the bypass pipe with a torque value of 60 N-cm.

⚠ CAUTION

For fastening the bypass pipe, use a torque wrench. If the bolts are tightened firmly without using the torque wrench, the screw insulators might be damaged.

---

21) If the I-shaped pipe is being removed, fasten it on the coil pipe joint with the two M4 ×18 Stn.Stl. bolts with the same procedure as fastening the bypass pipe. At this time, set the packing on the packing groove of the I-shaped pipe. The packing should be set in a correct direction. As is shown in Fig. 5-29, the cross section of the packing is a trapezoid. Set the packing so that the longer base of the packing is faced toward the packing groove.

⚠ CAUTION

Be sure to set the packing on the I-shaped pipe and be careful to set the packing so that it should be set in a correct direction.

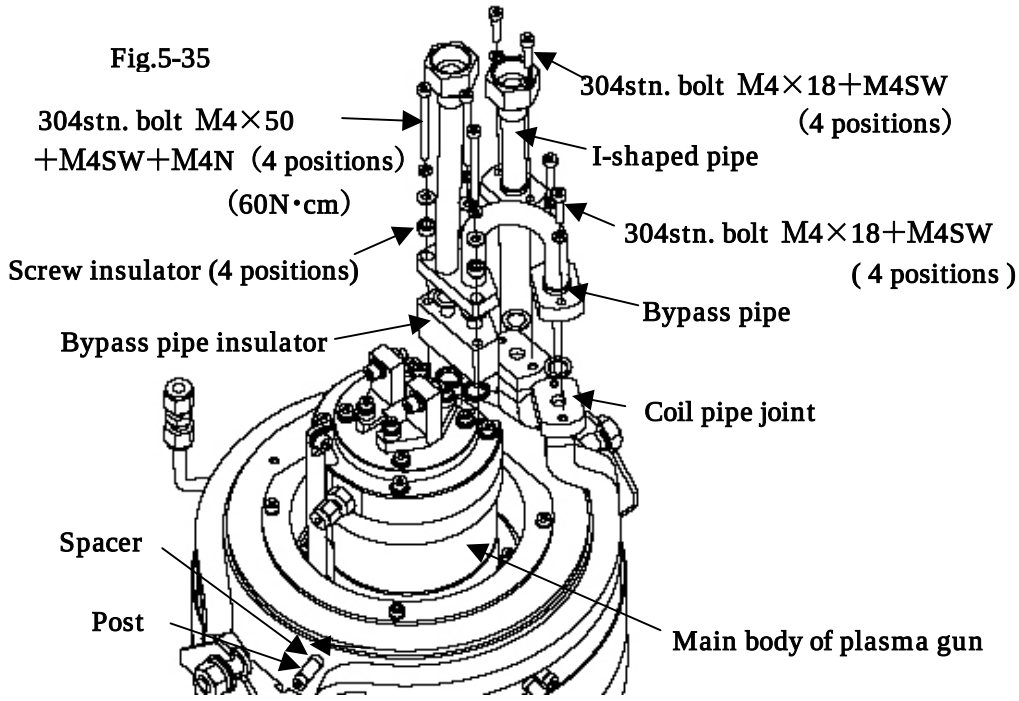
---

22) Fasten the stopper on the coil with the four M4×8 Stn.Stl. bolts. At this time, set the M4 Stn.Stl. spring washers (SW) on the Stn.Stl. bolts. Fasten the stopper with a torque value of 15 N-cm.

⚠ CAUTION

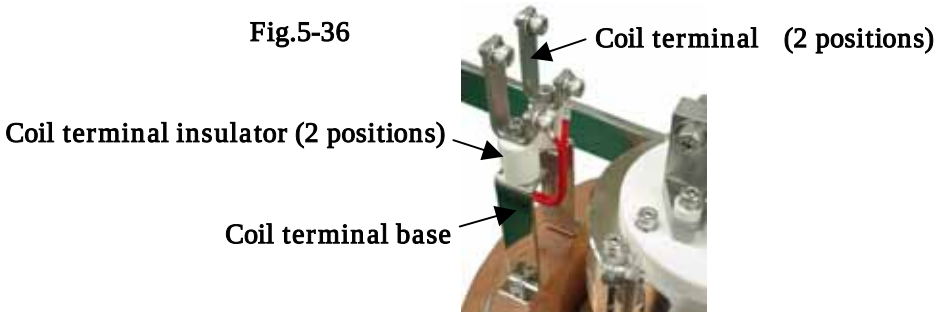
For fastening the stopper, use a torque wrench. If the bolts are tightened firmly without using the torque wrench, the anode insulators might be damaged.

Fig.5-35



２３）The coil terminal section shown in Fig.5-36 is a portion that is not disassembled and assembled at maintenance and inspection for the plasma source. Periodically check if the Stn.Stl. bolts that fasten each part of the coil terminal section are loosened or not. If any loose bolt is found, tighten it.

Fig.5-36

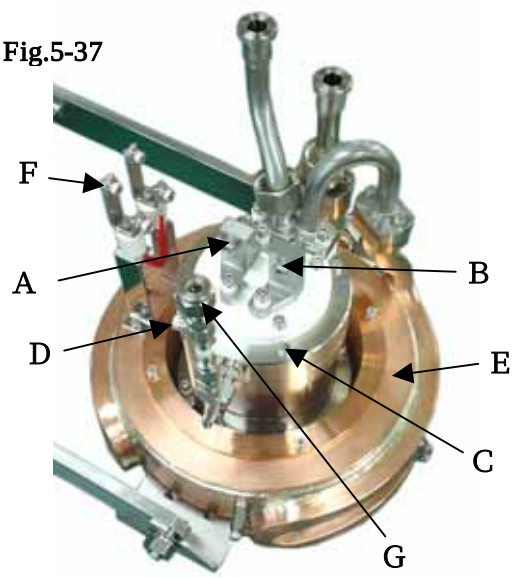


２４）Apply a tester between each electrode terminal and each part shown in Fig.5-37, and measure the electric resistance value of each of the following items ①to⑨. Check if the resistance value is 100 kΩ or more. If the resistance value is below 100 kΩ, check if the insulator used in the section is not contaminated. If a detective portion is found, repair it.

※Measure the electrical resistance after removing the wires and the discharge gas pipe from the plasma source and stopping the cooling water for the gun.

①Between A (filament terminal) and B (filament terminal) ※Without filament
②Between A (filament terminal) and C (flange) ※Without filament
③Between B (filament terminal) and C (flange) ※Without filament
④Between D (anode electrode terminal) and C (flange)
⑤Between C (flange) and E (coil)
⑥Between D (anode electrode terminal) and E (coil)
⑦Between F (coil terminal) and E (coil)
⑧Between C (flange) and G (1/4-1/8 Union)
⑨Between H (I-shaped pipe) and E (coil)

Fig.5-37

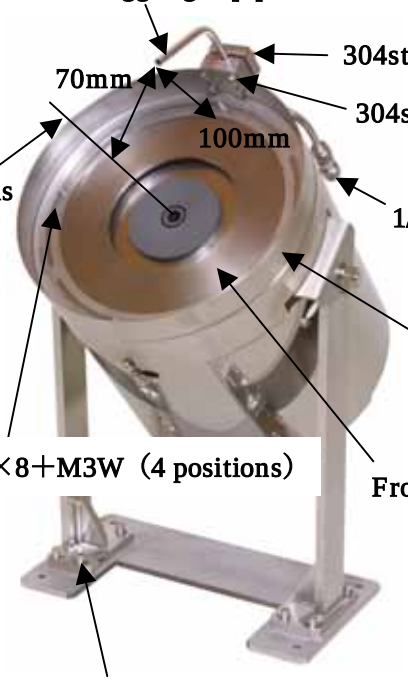


２５）Shield the plasma source with the trestle, the coil lateral-side deposition-proof cover and the lateral-side deposition-proof cover by reversing the operations shown in Steps 1) to 5) in Section 5.4.4.1.

２６）Attach the anode, nozzle, pipe, ring and orifice parts by referring to Sections 5.4.1 to 5.4.3.

２７）The trigger gas pipe section shown in Fig.5-38 is a portion that is not disassembled and assembled at maintenance and inspection for the plasma source. Adjust the layout of the trigger gas pipe section according to necessities. The adjustment of the trigger gas pipe section is carried out by loosening the two M4×16 Stn.Stl. bolts and the four M3×8 Stn.Stl. bolts shown in Fig.5-38. At the shipment from the factory, this section is set in a place where it is 100 mm distant from the front deposition-proof cover and distant from 70 mm from the beam central axis. Note that this section is sometimes not necessary depending on usage. In this case, keep it removed.

Fig.5-38


Trigger gas pipe
304stn. bolt M4×16（2 positions）
70mm
304stn. bolt M4×6（4 positions）
100mm
Beam center axis
1/4 Union
Anode deposition-proof cover
304stn. bolt M3×8＋M3W（4 positions）
Front deposition-proof cover
304stn. bolt M5×15＋M5SW＋M5N（8 positions）

5．5 Maintenance Parts List

The maintenance parts (consumables and replacement parts) for the built-in plasma source are as follows. When placing an order for maintenance parts, designate parts name, parts number, and quantity.

Table 5-4 Consumables List

Parts name	PNo.	Specification	Replacement interval	Replacement time
Filament	7804 04769	Tungsten (10pieces)	70h	—
Anode	8124 96710	Carbon	300h	Refer to 5.4.1.
Nozzle	8122 63677	Carbon	70h	Refer to 5.4.1.
Pipe	8202 31924	Carbon	500h	Refer to 5.4.2.
Ring	8116 90911	Carbon	1000h	Refer to 5.4.2.
Orifice	8121 94748	Carbon	150h	Refer to 5.4.2.
High-melting-point screw	4090 16462	Molybdenum M3×6	200h	—
High-melting-point screw	4090 17248	Molybdenum M3×8	500h	—
High-melting-point screw	8201 33205	Molybdenum M4×30	500h	—
High-melting-point screw	4090 17434	Molybdenum M6×14	200h	—
Spacer (Ring section)	8202 68054	304stn.	1000h	—

※The list of consumable items gives nominal replacement times for reference.
Replacement time varies depending on the operating conditions of the plasma gun.
※The order unit for the filament and high-melting-point screw is ten pieces each.

Table 5-5 Replacement Parts List

Parts name	PNo.	Specification	Replacement interval
O-ring (Gas pipe joint section)	4060 02088	AS568-011 (fluorocarbon rubber) (Fig.5-32)	6 months
Packing	8202 08221	fluorocarbon rubber (Fig.5-29)	6 months
Holder	8202 29075	Molybdenum (Fig.5-18)	1 year
Support	8124 99093	Molybdenum (Fig.5-18)	1 year
Rod	8201 80041	Molybdenum (Fig.5-19)	1 year
Holder insulator	8124 99085	Si3N4 (Fig.5-21)	1 year
Flange insulator	8202 70890	Si3N4 (Fig.5-32)	1 year
Anode electrode flange	8116 70201	304stn.stl. (Fig.5-4)	1 year
Bypass pipe	8107 52697	304stn.stl. (Fig.5-34)	1 year
Coil terminal insulator	3270 00589	Steatite (Fig.5-36)	1 year
Bypass pipe insulator	8201 72189	Alumina (Fig.5-35)	1 year
Screw insulator	8112 58521	Alumina (Fig.5-26)	1 year

※The list of the replacement parts gives nominal replacement times for refernce. If you handle the parts properly ,you can prolong the replacement times. Any order for parts after the replacement times requires payment.

Table 5-6 Component Parts List

Parts name	PNo.	Specification
Flange	8116 72000	304stn.stl. (Fig.5-19)
Coil	8018 19091	(Fig.5-24)
Coil terminal	8121 94870	304stn.stl. (Fig.5-36)
Coil terminal base	8202 31941	304stn.stl. (Fig.5-36)
Coil cover	8106 72545	Oxygen-free copper (Fig.5-23)
Front deposition-proof cover	8116 71267	304stn.stl. (Fig.5-23)
Anode deposition-proof cover	8116 69734	304stn.stl. (Fig.5-23)
Coil lateral-side deposition-proof cover	8116 71291	304stn.stl. (Fig.5-23)
Anode insulator	8106 71999	Si3N4 (Fig.5-28)
Heat sink	8018 19300	304stn.stl. (Fig.5-26)
Anode electrode terminal	8202 29164	303stn.stl. (Fig.5-26)
Stopper	8106 72685	Oxygen-free copper (Fig.5-25)
I-shaped pipe	8116 70325	304stn.stl. (Fig.5-35)
Bracket (right)	8116 71330	304stn.stl. (Fig.5-24)
Bracket (left)	8116 71321	304stn.stl. (Fig.5-24)
Post	8107 35113	304stn.stl. (Fig.5-22)
Base	8107 53022	304stn.stl. (Fig.5-22)
Lateral deposition-proof cover (big)	8116 71305	304stn.stl. (Fig.5-22)
Lateral deposition-proof cover (small)	8116 71313	304stn.stl. (Fig.5-22)
Holder (Trigger gas pipe section)	8202 31037	304stn.stl. (Fig.5-22)
Support (Trigger gas pipe section)	8202 31045	304stn.stl. (Fig.5-22)
1/8 SUS pipe	8202 31053	304stn.stl. (Fig.5-32)
Trigger gas pipe	8116 72255	304stn.stl. (Fig.5-23)
Gas pipe joint	4030 26245	304stn.stl. (Fig.5-32)
1/8 Union	4030 09669	SS-200-6/SWAGELOK (Fig.5-32)
1/4 Union	4030 08891	SS-400-6/SWAGELOK (Fig.5-38)
1/8-1/4 Union	4030 11205	SS-400-6-2/SWAGELOK (Fig.5-32)
Isolator	4030 32733	9611002/ISI (Fig.5-32)
Spacer (Coil section)	8124 90819	303stn.stl. (Fig.5-35)
Post (Coil section)	3900 10791	303stn.stl. (Fig.5-35)

Table 5-7 Jig Parts List

Parts name	PNo.	Specification
Jig A	8122 64452	Brass
Jig B	8122 64444	Brass
Jig C	8202 58873	304stn.stl.
Jig C	8645 56420	304stn.stl.

Table 5-8 JIS Standard Parts List

Parts name	PNo.	Specification
M2.6×8	4090 06785	304stn.stl. Phillips flat head screw
M3×8	4110 02775	304stn.stl. hexagon socket head bolt
M4×5	4110 09516	304stn.stl. hexagon socket head bolt
M4×6	4110 02783	304stn.stl. hexagon socket head bolt
M4×8	4110 02481	304stn.stl. hexagon socket head bolt
M4×16	4110 03879	304stn.stl. hexagon socket head bolt
M4×30	4110 09168	304stn.stl. hexagon socket head bolt
M4×50	4110 03721	304stn.stl. hexagon socket head bolt
M5×8	4110 04450	304stn.stl. hexagon socket head bolt
M5×15	4110 00209	304stn.stl. hexagon socket head bolt
M5×20	4110 00217	304stn.stl. hexagon socket head bolt
M4SW	4120 01683	304stn.stl. M4 spring washer
M4W	4120 03821	304stn.stl. M4 washer
M5SW	4120 01691	304stn.stl. M5 spring washer
M5W	4120 01845	304stn.stl. M5 washer
M10SW	4120 01021	304stn.stl. M10 spring washer
M10W	4120 01870	304stn.stl. M10 washer
M10N	4120 00946	304stn.stl. M10 nut

※The order unit for JIS standard parts is ten pieces.

6. Troubleshooting

6. 1 Precautions at Occurrence of an Equipment Failure

WARNING

When an equipment failure occurs, stop the operation at once. Otherwise, an electric shock or injury may be caused.

CAUTION

When a protective device such as an alarm, fuse, and breaker is actuated, do not restart the operation until the cause is found out. Otherwise, an injury or fire may be caused.

6. 2 Troubleshooting

When trouble occurs in the equipment, perform troubleshooting referring to Table 6-1. If any trouble other than those mentioned in Table 6-1 occurs or the equipment cannot be restored to the normal status by executing a corrective measure for the trouble, inform the service offices mentioned in Chapter 9 Service Call of it.

Table 6-1

Item	Cause	Corrective measure
(1) Discharge gas cannot flow.	①The gas cylinder is plugged up. ②The residual quantity in the gas cylinder is small or the gas cylinder is empty. ③The discharge gas flow rate is set to zero. ④The solenoid valve is not operated. ⑤The gas pipe, solenoid valve, or mass flow controller is clogged up.	①Unplug the gas cylinder. ②Replace the gas cylinder. ③Set the gas flow rate to 8mL/min or more. ④Check the connection of the solenoid valve cable and repair the defective portion. ⑤Clear the clogged status in the gas pipe. For a clogged status in the solenoid valve or mass flow controller, consult with JEOL Ltd.

Item	Cause	Corrective measure
(2) Cooling water cannot flow. Cooling water cannot reach the set flow rate.	①The differential pressure between feed water and discharge water is low. ②The cooling water pipe is clogged. ③The stop valve for the cooling water pipe is closed. ④The cooling water pipe of the plasma source is clogged with fur.	①Increase the differential pressure. ②Clear the clogged status in the cooling water pipe. ③Open the stop valve. ④Disassemble the plasma source and remove the fur.
(3) A coil current cannot flow.	①The wire between the coil power supply and the coil terminal is not connected correctly. ②The NF6 breaker switch is OFF. ③The coil power supply is in an emergency stop.	①Check the wire connection and repair the defective portion. ②Turn on the NF6. ③ After setting the ON/OFF switches of the coil power supply to RESET, return to OFF and then set to ON.
(4) A filament current cannot flow. The filament current is restricted.	①The wire between the filament power supply and the filament fastening section is not connected correctly, or the wire connecting section is loose. ②The filament power supply NFB is OFF.	①Check the wire connection and repair the defective portion. ②Check the NFB status of filament power supply .
(5) Plasma beams are unstable.	①The discharge gas flow rate is low. ②The operating pressure is improper. ③The coil current is improper. ④The conductivity of the anode surface is deteriorated. ⑤The life of the filament has expired or the filament is deteriorated. ⑥The discharge voltage is low. ⑦The conductivity of the vacuum chamber wall is deteriorated. (At irradiation beam) ⑧The insulation performance of the anode insulator is deteriorated.	①Increase the gas flow rate. ②Adjust the pressure. ③Adjust the coil current. ④Clean the anode surface. ⑤Replace the filament. ⑥Increase the discharge voltage ⑦Take a measure to keep the conductivity of the vacuum chamber wall. ⑧Clean the insulator.

Item	Cause	Corrective measure
	⑨The evaporation rate is not stable. ⑩The insulation performance of the filament unit insulator is deteriorated. ⑪Discharge gas has low purity.	⑨Make the evaporation rate stable. ⑩Clean the insulator. ⑪Use high-purity discharge gas. If not much gas remains in the cylinder (the pressure is less than 5 MPa) , replace the cylinder.
(6) Plasma beams do not spread out.	①The coil current is improper. ②A magnetized material exists near the plasma gun.	①Adjust the coil current. ②Change the layout of the plasma gun. Keep the magnetized material away from the plasma source.
(7) Plasma beams are not output.	①The discharge gas flow rate is low. ②The operating pressure is improper. ③The coil current is improper. ④The conductivity of the anode surface is deteriorated. ⑤The life of the filament has expired or the filament is deteriorated. ⑥The discharge voltage is low. ⑦The conductivity of the vacuum chamber wall is deteriorated. (At irradiation beam) ⑧The insulation performance of the anode insulator is deteriorated. ⑨Discharge gas is not supplied. ⑩Discharge gas has low purity. ⑪The vacuum lead wire for the filament or anode is short-circuited with another wire or ground material.	①Increase the gas flow rate. ②Adjust the pressure. ③Adjust the coil current. ④Clean the anode surface. ⑤Replace the filament. ⑥Increase the discharge voltage ⑦Take a measure to keep the conductivity of the vacuum chamber wall. ⑧Clean the insulator. ⑨Check the connection of the discharge gas pipe and repair the defective portion. ⑩Use high-purity discharge gas. If not much gas remains in the cylinder (the pressure is less than 5 MPa) , replace the cylinder. ⑪Check if the lead wire is not short-circuited. Repair the defective portion.
(8) The life of the filament is short.	①A leak occurs in the discharge gas piping section (atmospheric side). ②Discharge gas is not caused to flow while the filament is heated.	①Repair the leaking portion. ②Cause discharge gas to flow. Do not introduce any reactive gas in the vacuum chamber while the filament is heated.

Item	Cause	Corrective measure
	③At a plasma beam output, the filament current is set at a low value (35 A or less). ④During a plasma beam output, an emergency stop of the power supply is often caused by interlock or alarm. ⑤Plenty of oxygen is introduced near the anode. ⑥The filament current is suddenly varied by manual operation. ⑦Discharge gas has low purity.	③Adjust the operating pressure, discharge gas flow rate, and discharge voltage to increase the filament current. ④Find out the cause for the emergency stop of the power supply and take a measure to avoid the emergency stop. ⑤Change the process gas introducing method. ⑥Try to vary the filament current slowly. ⑦Use high-purity discharge gas. If not much gas remains in the cylinder (the pressure is less than 5 MPa) , replace the cylinder.
(9) When water is caused to flow to the plasma source, the water leaks from the plasma source.	①The O-ring in the plasma source is deteriorated or damaged. ②The anode insulator, pipe insulator, or bypass pipe insulator is fissured or damaged. ③The anode electrode flange, filament unit flange, or other weld is cracked. ④The cooling water pipe is improperly connected. ⑤Corrosion originating in water contaminations has damaged a part inside the plasma source.	①Replace the O-ring. ②Replace the insulator. ③Replace the part having a welding crack. ④Repair the defective portion of pipe connection. ⑤Disassemble the plasma source and replace the corroded part with a new one. Check the water quality and take mea- sures to meet the specification.
(10) An evacuating operation cannot be attained.	①The O-ring in the plasma source is deteriorated or damaged. ②The anode insulator, pipe insulator, or bypass pipe insulator is fissured or damaged. ③The anode electrode flange, filament unit flange, or other weld is cracked. ④The cooling water pipe is improperly connected. ⑤A leak occurs in the discharge gas piping section (atmospheric side). ⑥A leak occurs on the feedthrough section.	①Replace the O-ring. ②Replace the insulator. ③Replace the part having a welding crack. ④Repair the defective portion of pipe connection. ⑤Repair the leaking portion. ⑥Repair the leaking portion.

Item	Cause	Corrective measure
	⑦Corrosion originating in water contaminations has damaged a part inside the plasma source.	⑦Disassemble the plasma source and replace the corroded part with a new one. Check the water quality and take mea- sures to meet the specification.
(11) The anode cannot be removed.	①The anode is deposited on the electrode flange. ②The anode inserting section of the anode electrode flange is much deformed by heat.	①Apply alcohol to the anode inserting section and pull out the anode while tapping it with a soft material. ②Consult with JEOL Ltd.

7. Precautions When Disposing Equipment

■Disposed equipment will cause environmental pollution. When disposing this product, dispose of it properly as industrial waste.

8. Warranty

8. 1 Contents of Warranty

8. 1. 1 Term of warranty

The term of warranty shall be 12 months after acceptance inspection at delivery to you on the premise that the product should be used in the normal operating conditions specified in this instruction manual. If the product is repaired within the term of warranty, the time required for repair shall not be added to the term of warranty.

8. 1. 2 Scope of indemnity

1）Troubleshooting

Inform us of the condition, contents, and other information of trouble. We shall perform troubleshooting according to the condition, contents, and other information of the trouble. When a failure occurs within the term of warranty and the product has been used in the specified operating conditions, we shall repair the product free of charge if we recognize that the cause of the failure is attributable to our responsibility. In the other cases, the product shall be repaired with charge.

2）Repairing method

When we judges that a failure should be repaired on our responsibility, we shall replace the product with an alternative one or repair it free of charge. We shall hold the right of choice in this case. Even if a failure occurs within the term of warranty, the product shall be repaired with charge in the following cases.

①The cause of a failure is attributable to improper handling or storage on your side or the software or hardware installed on your side.

②A failure is caused by modifying our product on your side.

③A failure is caused in the product which has been partly modified according to the specifications submitted by you that are different from our specifications.

④Wear is caused by your operating conditions.

⑤Proper maintenance is omitted.

⑥The product has been destructed or failed by natural disasters (earthquake, lightning, fire, storm and flood, etc.).

⑦We admit that the cause is not attributable to our responsibility.

⑧A failure is caused by exchange of the part which was not made in our company , or do not get authorization of our company .

8．1．3 Exemption from the obligation for indemnity

Regardless of the term of warranty, the indemnity for damage or loss of devices or machines other than our product on your side that is attributable to a failure of our product shall be exempted from our warranty. A warranty for the liability for manufacturing and maintenance of the equipment that was delivered to you 10 years or more ago shall also be exempted from our warranty.

8．2 Conditions for Acceptance Inspection

Regarding the acceptance inspection for the built-in plasma source and Plasma Source Control Power Supply, we verify the performance described in this instruction manual at our factory (Beam output operation is executed according to the procedure for inspecting our product.). After that, the product is delivered to your installation place, the cables attached to the product are connected, and then performance checks (beam output operation) are made. With this, the acceptance inspection is completed.

The various types of work required for connecting the built-in plasma source and the Plasma Source Control Power Supply described in Chapter 4 Preparations for Operation and the arrangement of vacuum parts shall be excepted from the conditions for acceptance inspection.

9. Service Call

■When making inquiries about trouble, maintenance, and technical issues of this product, make contact with the following offices.

【Where to make contact about product service】

☆East Japan Area

JEOL DATUM LTD. Tokyo IE Group
1156 Nakagami-cho , Akishima-shi , Tokyo
196-0022
TEL：042-542-2327 FAX：042-542-2156

☆West Japan Area

JEOL DATUM LTD. Osaka IE Group
Shin Osaka IN Bldg. 1F, 5-14-5, Nishi-Nakanosima, Yodogawa-ku, Osaka
532-0011
TEL：06-6304-3954 FAX：06-6303-5426

※When making an inquiry, be sure to inform us of the name of your equipment.

10. Application of This Product

This product cannot be used for a device or system that is operated in a condition that may affect people's lives.

When considering a specific application of this product, be sure to consult with us beforehand.

When transferring this product to your group company or another company, be sure to consult with us beforehand.

When moving this product overseas, be sure to consult with us beforehand.

When disposing this product, be sure to consult with us beforehand.

The warranty and service of this product are limited to domestic use. The warranty and service for overseas use shall be separately contracted with you in accordance with an agreement provided by us.