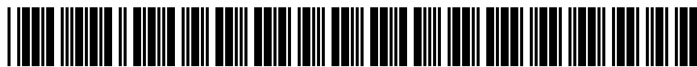

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(54) **ION SOURCE**

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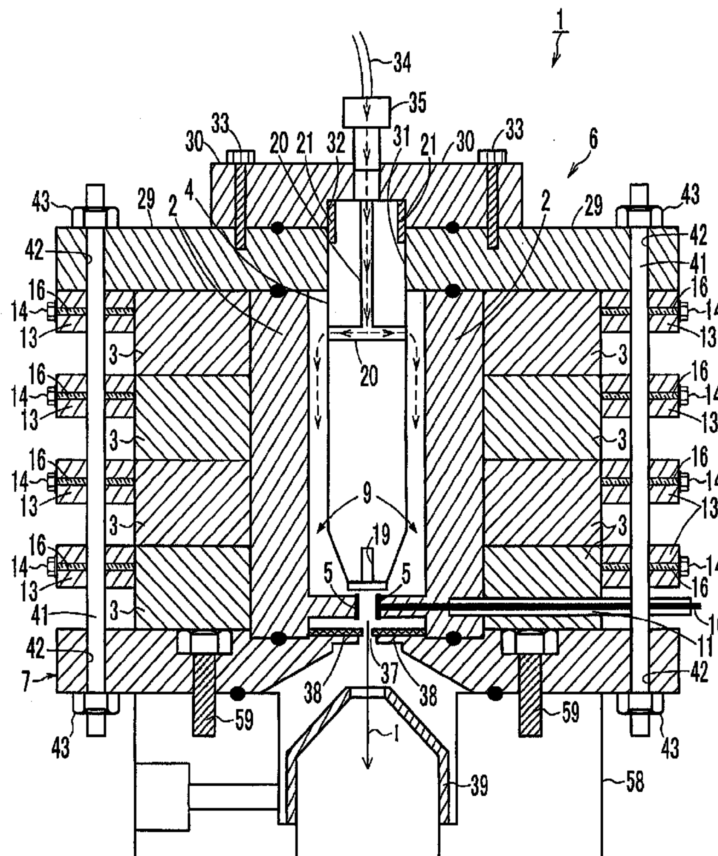
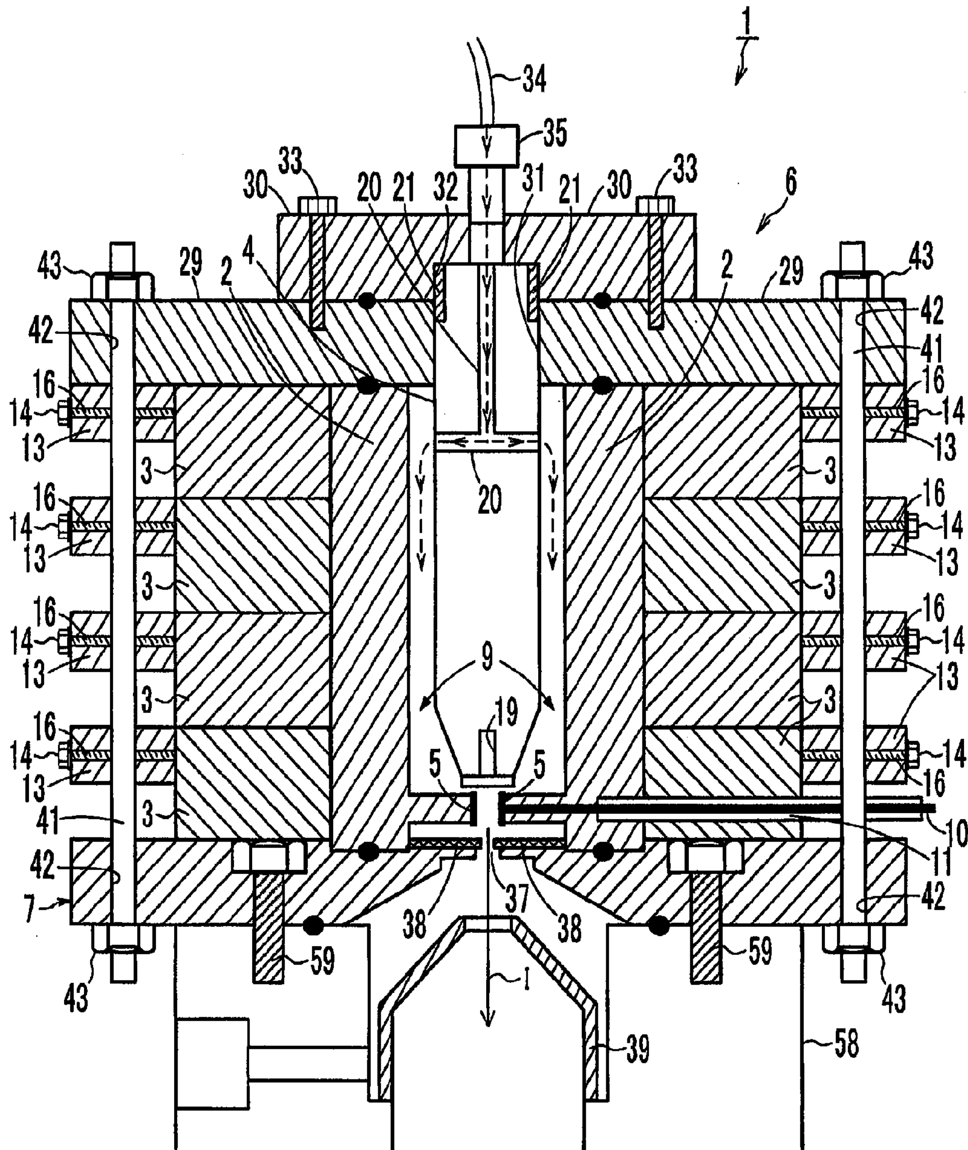
(57) **ABSTRACT**

It is a technical challenge to provide a small-sized ion source excellent in operability.

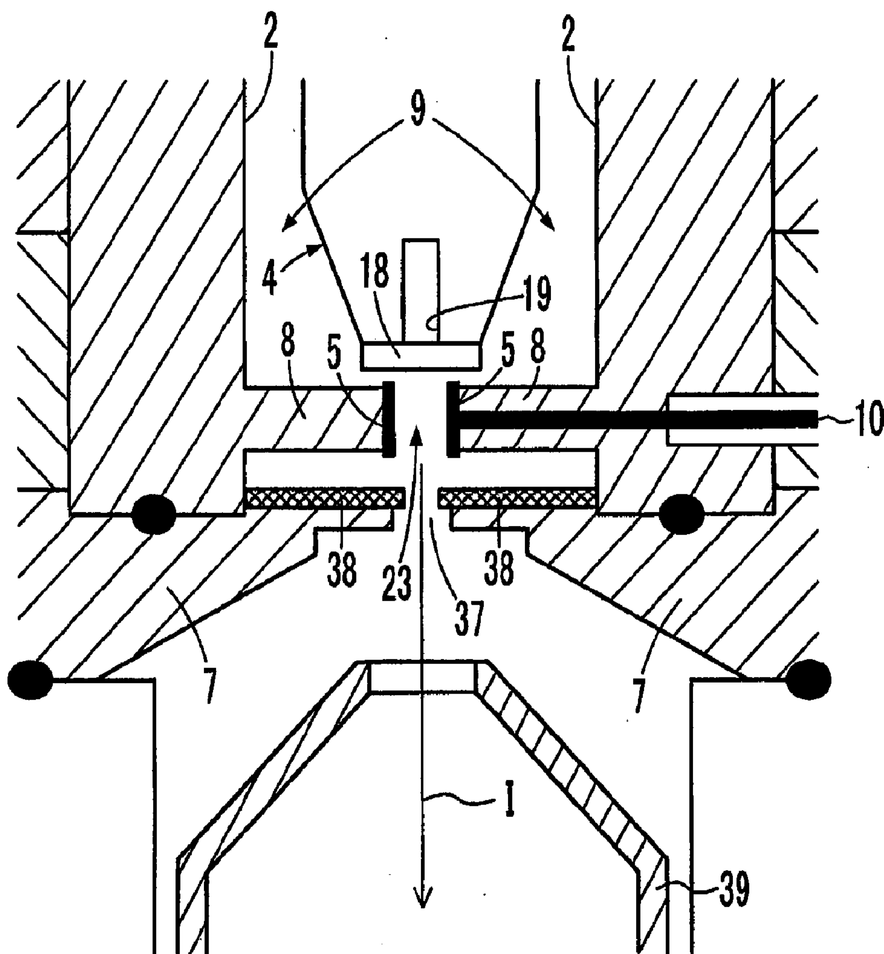
An ion source of the present invention includes: a cylindrical insulation tube (**2**) opened upward and opened at part of its lower surface; a plurality of hollow cylindrical permanent magnets (**3**), provided on the outer peripheral surface of the insulation tube to be arranged in a row in the axial direction of the insulation tube; a gas supplying means (**34, 35, 20**) for supplying gas into the insulation tube; a cathode electrode, at the tip end of which a fitting unit (**19**) for fitting of a solid material (**18**) there to is formed; an annular anode electrode (**5**), which is fitted to an opening in the lower surface of the insulation tube; an upper frame (**6**), which blocks the upper portion of the insulation tube and suspends the cathode electrode so as to allow the fitting unit to approach the anode electrode; and a lower frame (**7**), in which an extraction port (**37**) is formed for extracting ions emitted from the anode electrode, and on which the insulation tube is mounted.



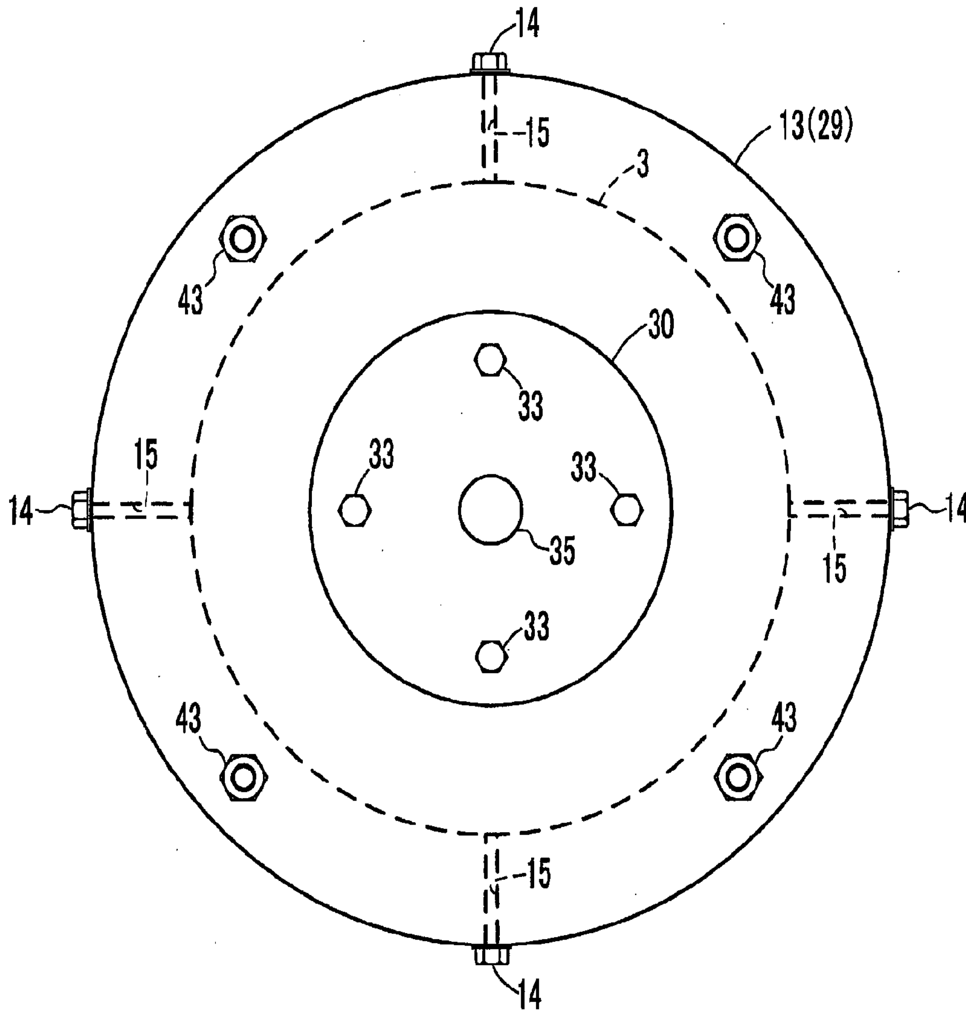
【FIG.1】



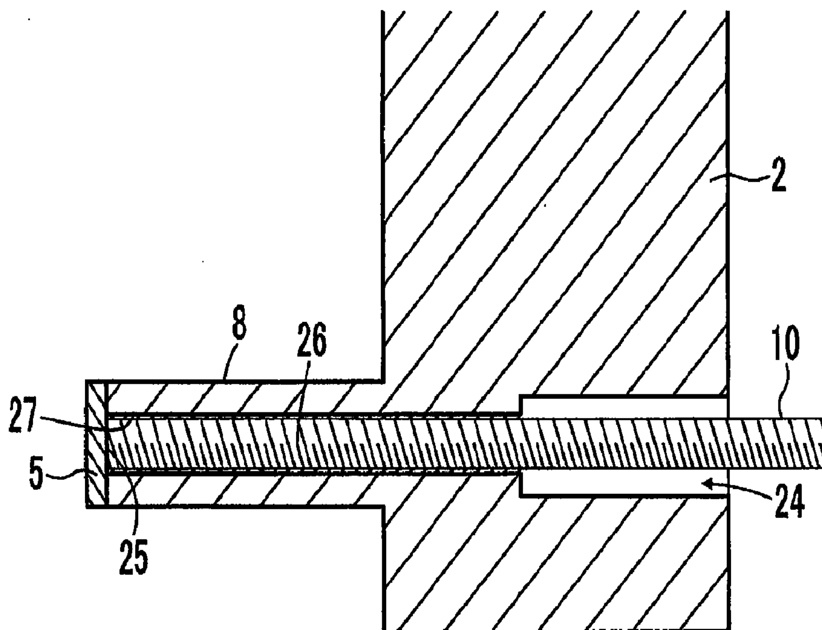
【FIG.2】



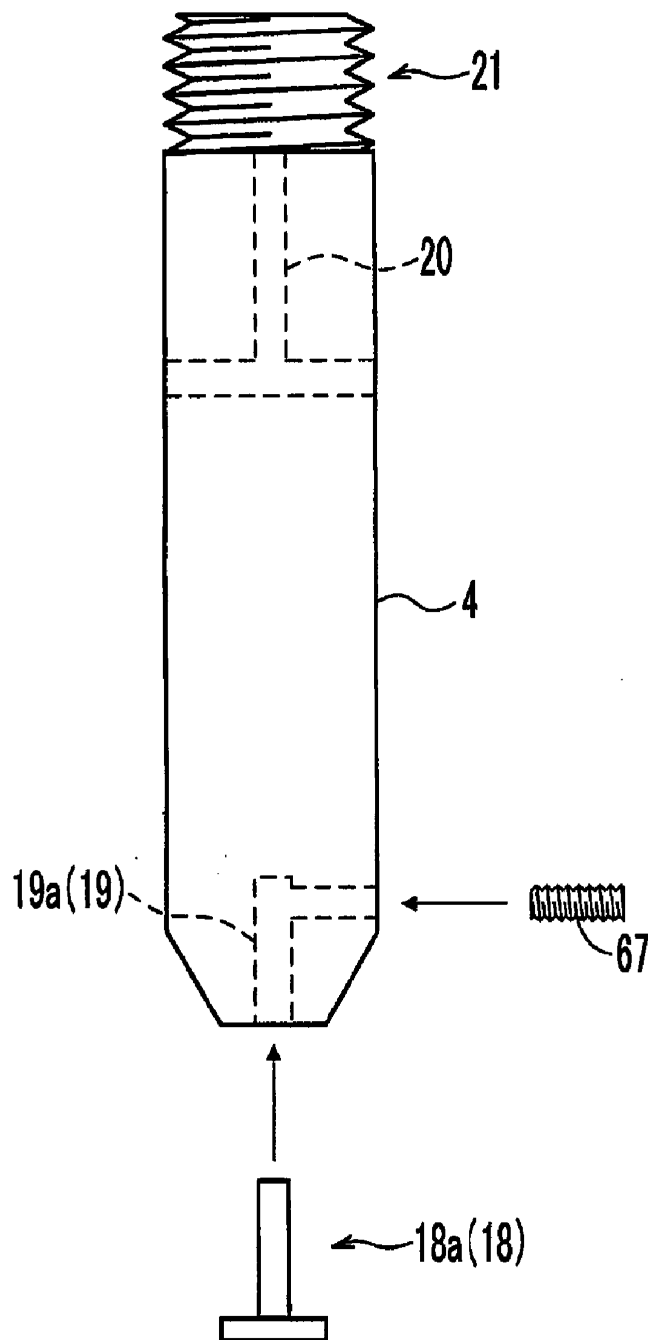
【FIG.3】



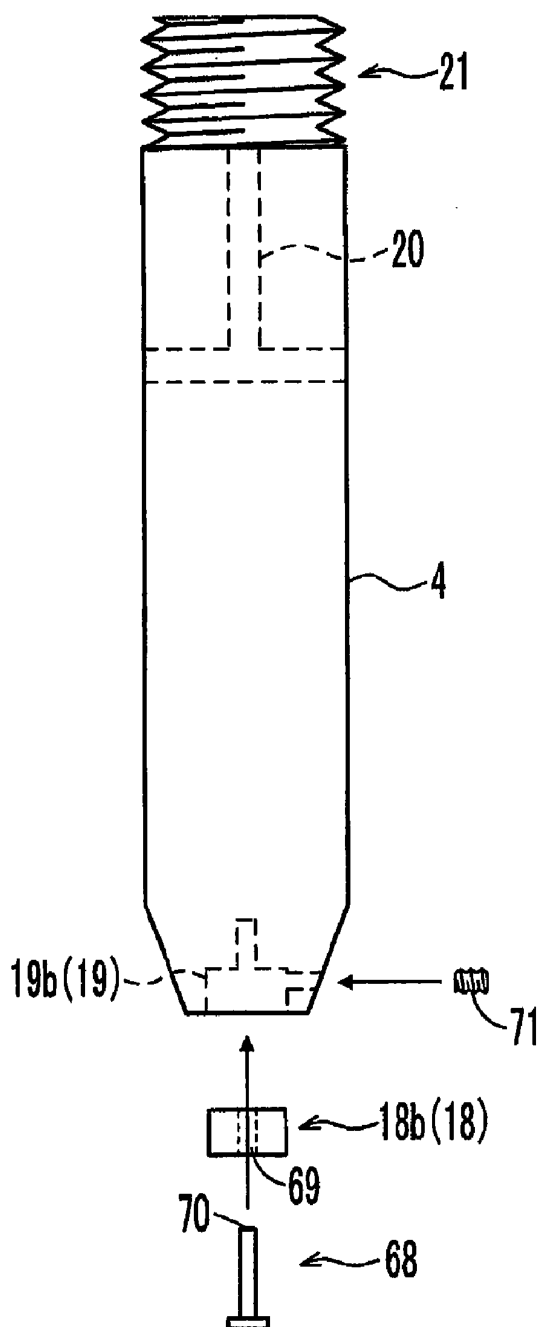
【FIG.4】



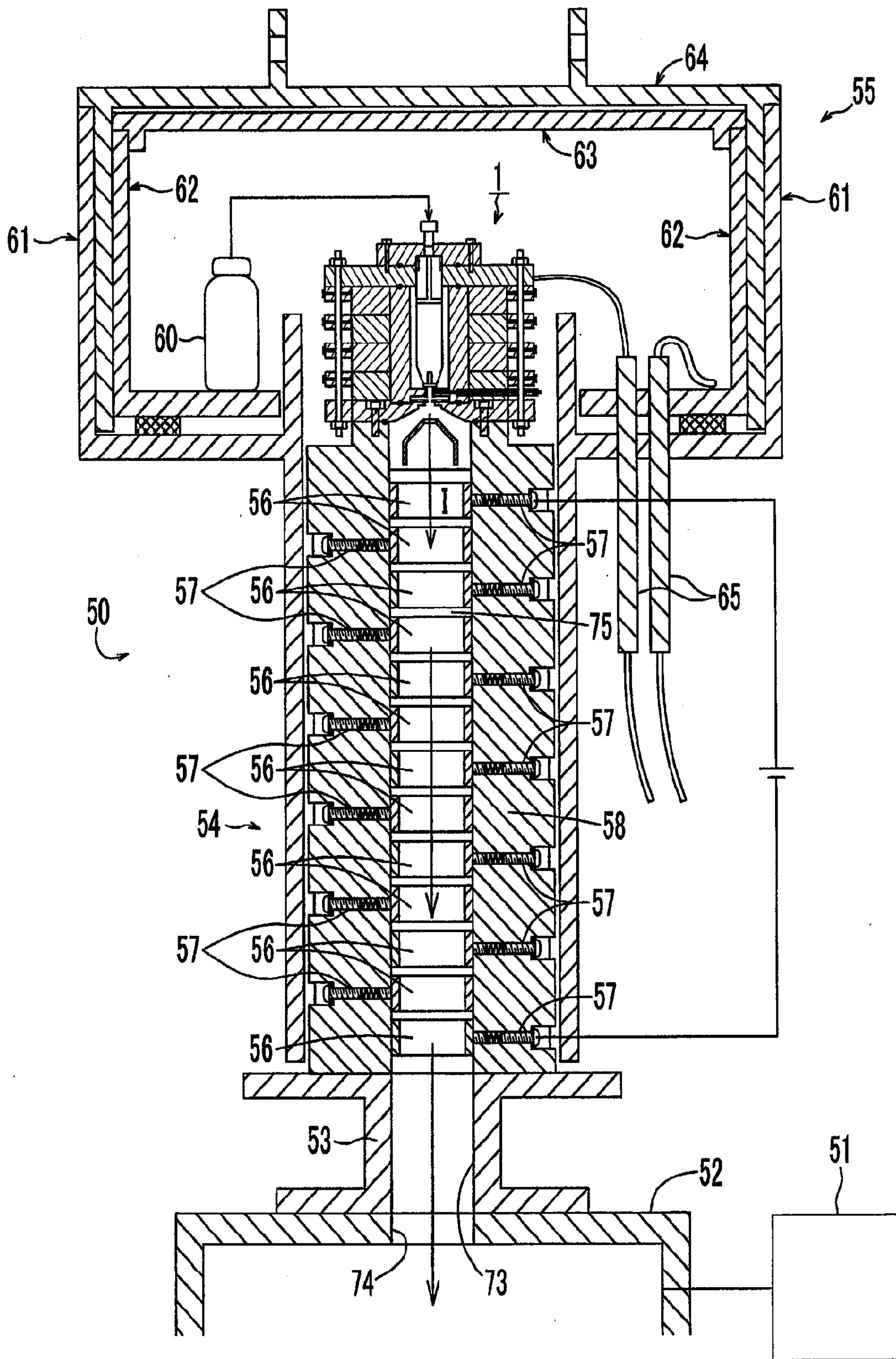
【FIG.5】



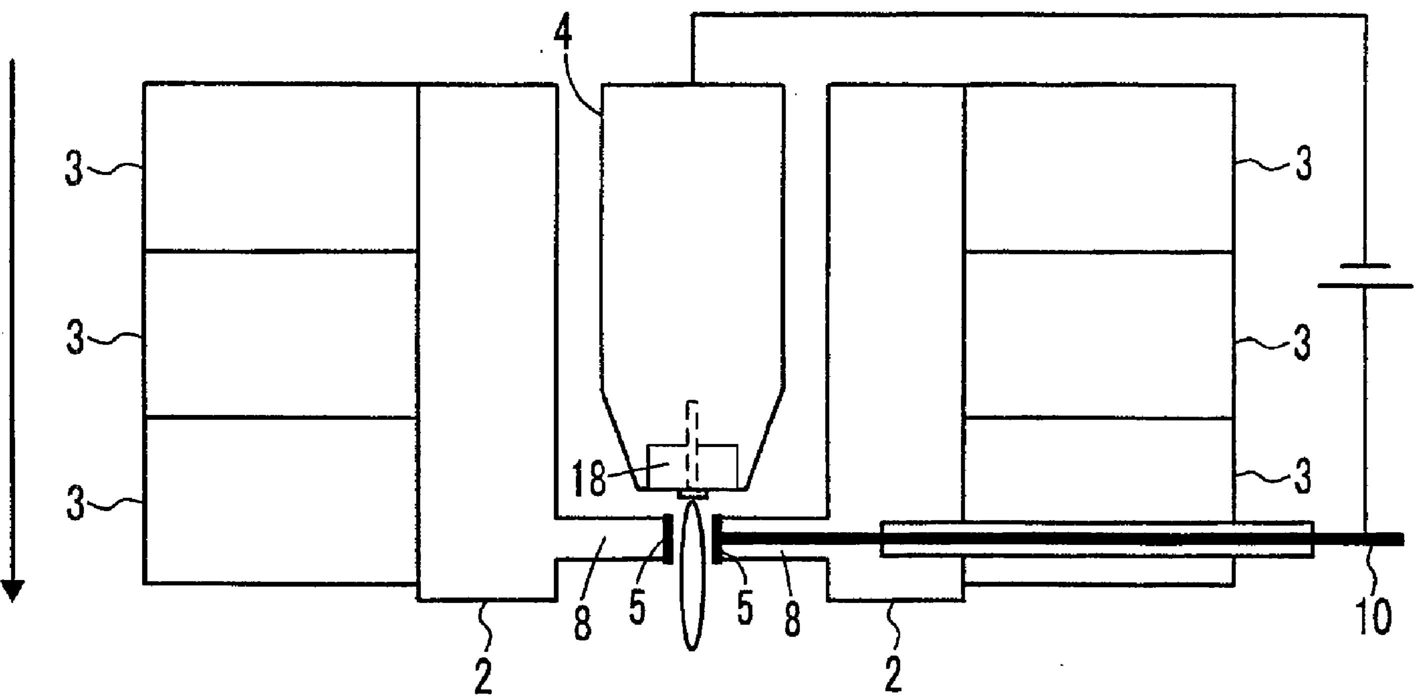
【FIG.6】



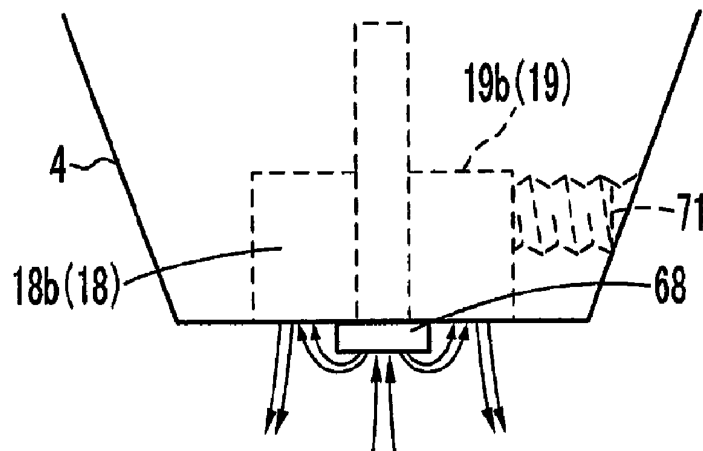
【FIG.7】



【FIG.8】



【FIG.9】



ION SOURCE

TECHNICAL FIELD

[0001] The present invention relates to an ion source, and specifically a sputter type ion source which sputters the surface of a solid material to generate ions.

BACKGROUND ART

[0002] As a technique of this kind, there has hitherto been a sputter type ion source of a so-called hot cathode system, in which a sputter electrode is constituted of a material intended to be ionized and a negative voltage is applied to the sputter electrode to emit sputter particles, and the emitted sputtered particles are ionized through the use of thermo-electrons emitted from a filament (see Patent Document 1, for example). Patent Document 1: Japanese Patent Laid-Open Application No. 2003-306767

DISCLOSURE OF INVENTION

Problems that Invention is to Solve

[0003] In the sputter type ion source of the hot cathode system as the device disclosed in Patent Document 1, there have been cases where a filament is heated to high temperature, and an electromagnet is additionally used for concentrating plasma, thereby requiring a cooling device or the like. This has caused a problem of increasing the ion source in size.

[0004] As opposed to this, a sputter type ion source of a so-called cold cathode system has been contrived, with a simple electrode structure as compared with that of the hot cathode system, but many of such ion sources have complicated device configuration, thereby causing a problem of preventing the user from readily making cleaning, maintenance and the like of the device.

[0005] The present invention was made in view of the above problems, and has an object to provide a small-sized ion source excellent in operability.

Means to Solve the Problems

[0006] In order to achieve the above object, an ion source according to claim **1** is characterized by including: a cylindrical insulation tube, opened upward and opened at part of its lower surface: a magnetic field generating means, provided on the outer peripheral surface of the insulation tube; a gas supplying means for supplying gas into the insulation tube; a cathode electrode, at the tip end of which a fitting unit for fitting of a solid material thereto is formed, and which is arranged in the inner space of the insulation tube; an annular anode electrode, which is fitted to an opening in the lower surface of the insulation tube, to emit at its center ions generated in the inner space of the insulation tube; an upper frame, which blocks the upper portion of the insulation tube and suspends the cathode electrode so as to allow the fitting unit to approach the anode electrode; and a lower frame, in which an extraction port is formed for extracting ions emitted from the anode electrode, and on which the insulation tube is mounted.

[0007] An ion source according to claim **2** is characterized in that the magnetic field generating means are a plurality of hollow cylindrical permanent magnets provided on the outer peripheral surface of the insulation tube to be arranged in a row in the axial direction of the insulation tube.

[0008] An ion source according to claim **3** is characterized in that a handle is fixed to the outer peripheral surface of the plurality of permanent magnets.

[0009] An ion source according to claim **4** is characterized in that the gas supplying means is a gas feeding-in hole formed in the cathode electrode connected with a gas supply source.

[0010] An ion source according to claim **5** is characterized in that the cathode electrode fixes an insulating solid material to a fitting unit formed at its tip end by means of a pin which has conductive properties and is electrically connected with the fitting unit.

[0011] An ion source according to claim **6** is characterized in that a shaft inserted through an insertion hole formed in the upper frame and lower frame is fixed by clamping to couple the upper frame and the lower frame so that the insulation tube is fixed to the upper frame and the lower frame.

[0012] An ion source according to claim **7** is characterized in that the ion source is used as an ion source of an ion implanting device.

[0013] According to the ion source of claim **1**, since the cathode electrode is hanged by the upper frame, there is an advantage that the cathode electrode can be readily taken out from the insulation tube by pulling the upper frame upward so as to facilitate setting and the like of the solid material fitted to the fitting unit formed at the tip end of the electrode.

[0014] According to the ion source of claim **2**, since the permanent magnets are used as means for generating a magnetic field in the inner space of the insulation tube, it is not necessary to provide a cleaning means needed in the case of using an electromagnet, thereby allowing reduction in size of the ion source.

[0015] According to the ion source of claim **3**, there is an advantage that the permanent magnets strongly adhering to one another can be readily separated by holding the handles, so as to facilitate cleaning and maintenance of the ion source.

[0016] According to the ion source of claim **4**, since the gas feeding-in hole for supplying gas for discharge to the inner space of the insulation tube is formed inside the cathode electrode, the device is compact compared with the case of providing the gas feeding-in hole in another portion, thereby allowing reduction in size of the ion source.

[0017] According to the ion source of claim **5**, since fixing is made by means of the pin having conductive properties, not only a conductive solid material but also an insulating solid material can be used.

[0018] According to the ion source of claim **6**, the upper frame and the insulation tube can be readily removed by releasing the clamp of the shaft. This can facilitate cleaning and maintenance of the ion source.

[0019] According to the ion source according to claim **7**, there is an advantage that the use of the ion source as an ion source of an ion implanting device leads to improvement in operability of the ion implanting device.

BEST MODE FOR CARRYING OUT THE INVENTION

[0020] In the following, an ion source according to an embodiment of the present invention is described based upon FIGS. **1** to **9**. An ion source (charged-particle source) **1** according to the embodiment of the present invention is an ion source of a PIG (Penning Ionization Gauge) type using an orthogonal electromagnetic field, and includes an insulation tube **2**, a plurality of permanent magnets **3** as magnetic field generating means, a cathode electrode **4**, an anode electrode **5**, an upper frame **6**, and a lower frame **7**, as shown in FIG. **1**.

[0021] As shown in FIGS. **1** and **2**, the insulation tube **2** is a cylindrical container opened upward and opened at a part of its lower surface **8**. This insulation tube **2** is constituted of an insulating material and formed, for example, with an outer diameter of the order of 60 mm, an internal diameter of the order of 30 mm, a thickness of the order of 15 mm, and a length of the order of 80 mm. As the insulating material constituting this insulation tube **2**, for example, alumina, macol, boron nitride (BN), and the like can be cited. It is to be noted that the internal diameter, the external diameter, the thickness, the length and the like of the insulation tube **2** are not particularly restricted, but changeable as appropriated according to the need.

[0022] The permanent magnet **3** generates a magnetic field in the axial direction in an inner space **9** of the insulation tube **2** and is formed, for example, in hollow cylindrical shape with an outer diameter of the order of 120 mm, an internal diameter of the order of 60 mm, a thickness of the order of 30 mm, and a length of the order of 20 mm, as shown in FIGS. **1** and **3**. The plurality of (here, four) permanent magnets **3** are provided on the outer peripheral surface of the insulation tube **2** to be arranged in a row in the axial direction of the insulation tube **2**, and these plurality of permanent magnets **3** form a magnetic field in the axial direction with a magnetic flux density of the order of 500 Gauss in the inner space **9** of the insulation tube **2**. It is to be noted that on the permanent magnet **3** at the lowermost level, a through hole **11** is formed for insertion therethrough of an electrode rod **10** electrically connecting the anode electrode **5** and a direct current power source provided outside the figure. For this reason, the permanent magnet **3** at the lowermost level is made of iron magnetized in consideration of the strength.

[0023] A handle **13** is fixed to the outer peripheral surface of the permanent magnet **3**. A bolt hole **15** is formed in this handle **13** such that a bolt **14** penetrates the bolt hole **15** in its diameter direction. A female screw (not shown) into which a male screw **16** of the bolt **14** is screwed is formed in the bolt hole **15**. The male screws **16** of the bolt **14** is hinged into each of the bolt holes **15** from the outside and the tip end of the bolt **14** presses the outer peripheral surface of the permanent magnet **3** so that the handle **13** is fixed to the outer peripheral surface of each of the plurality of permanent magnets **3**. Therefore, by pulling this handle **13** upward, the user can relatively readily lift the permanent magnet **3** upward which absorbs another permanent magnet **3** by suction power of each other, so as to readily disassemble the ion source **1**. Although the permanent magnets **3** as thus described are desirably used as the magnetic field generating means since such a use avoids the need to provide a cleaning means and allows reduction in size of the ion source, electron magnets may also be used and these are also included in the present invention.

[0024] As shown in FIGS. **1**, **2**, **5**, and **6**, the cathode electrode **4** is formed, for example, in longitudinal cylindrical shape with an external diameter of the order of 20 mm and a height of the order of 90 mm. As metal constituting this cathode electrode **4**, for example, iron (Fe) is cited. In this cathode electrode **4**, a fitting unit **19** for fitting of a solid material **18** thereto is formed at the tip end, and as a gas supplying means, a gas feeding-in hole **20** is formed for supplying gas to the inner space **9** in the state of being arranged in the inner space **9** of the insulation tube **2**. As shown in the figure, the gas feeding-in hole **20** is formed to penetrate the inside of the cathode electrode **4** so as to connect the rear end of the cathode electrode **4** and the outer peripheral surface of the cathode electrode **4**, and gas for discharge or material gas can be supplied to the inner space **9** of the insulation tube **2** through this gas feeding-in hole **20**. Further, a male screw **21** for coupling the cathode electrode **4** to the upper frame **6** is formed in the vicinity of the rear end of the outer peripheral surface of the cathode electrode **4**. As for the gas supply means, it is desirable to form the gas feeding-in hole for supplying gas for discharge to the inner space of the insulation tube inside the cathode electrode as in the present embodiment, since the device becomes compact as compared with the case of providing the gas feeding-in hole in another portion, thereby to allow reduction in size of the ion source. However, for example, the gas feeding-in hole may be formed in another portion in a method where the gas feeding-in hole is provided in a frame plate **29** and a hanging member **30** and gas is supplied to the inner space **9**, a method where the gas feeding-in hole is provided in the permanent magnet **3** and the insulation tube **2** and gas is supplied to the inner space **9**, and some other methods, and these are also included in the present invention.

[0025] As shown in FIGS. **1**, **2**, **4**, and **8**, the anode electrode **5** is formed in annular shape so as to be joined with an opening **23** of the lower surface **8** of the insulation tube **2**. As metal constituting this anode electrode **5**, for example, tungsten (W) is cited. A thorough hole **24** for penetration therethrough of the electrode rod **10** in the diameter direction of the insulation tube **2** is formed on the lower surface **8** of the insulation tube **2**, with which anode electrode **5** is joined, and a tip end **25** of the electrode rod **10** provided to penetrate the through hole **24** and be in intimate contact with the insulation tube **2** is in contact with the outer peripheral surface of the anode electrode **5** while a rear end of the electrode rod **10** is electrically connected to the direct current power source, so that the anode electrode **5** is electrically connected with the direct current power source.

[0026] It is to be noted that the male screw **26** is formed in the electrode rod **10** while a female screw **27** is formed in part of the through hole **24**, and the electrode rod **10** is hinged into the through hole **24** from the outside. In addition, as metal constituting the electrode rod **10**, for example, stainless is cited.

[0027] As shown in FIGS. **1** and **3**, the upper frame **6** hangs the cathode electrode **4** such that the upper portion of the insulation tube **2** is blocked and the fitting unit **19** approaches the anode electrode **5**, and is constituted of a frame plate **29** and a hanging member **30** in the present

embodiment. The frame plate **29** is formed, for example, in disc shape with an external diameter of the order of 160 mm and a height of the order of 15 mm, and a cathode electrode insertion hole **31** is formed such that the cathode electrode **4** can be inserted therethrough. As a material constituting the frame plate **29**, for example, iron is cited. The hanging member **30** is formed in disc shape with an external diameter of the order of 80 mm and a height of the order of 13 mm, and its lower surface side, a concave portion **32** is formed, into which the rear end of the cathode electrode **4** is inserted. It is to be noted that the hanging member **30** is fixed to the frame plate **29** by means of a bolt **33**.

[0028] Although not shown in the figure, a female screw is formed in this concave portion **32** in its axial direction, and thereby, the male screw **21** on the rear end side of the cathode electrode **4** is hinged to the hanging member **30**. Therefore, the cathode electrode **4** can be taken out from the inner space **9** of the insulation tube **2** by removing the bolt **33** and lifting the hanging member **30** upward. This can facilitate setting of the solid material **18** to the fitting unit **19** of the cathode electrode **4**. Further, a coupling member **35** for coupling a gas tube **34** connected with the gas supply source provided outside the figure and the gas feeding-in hole **20** of the cathode electrode **4** is fixed to the upper surface side of the hanging member **30**, and gas is supplied to the inner space **9** of the insulation tube **2** through the gas tube **34**, the coupling member **35**, and the gas feeding-in hole **20**.

[0029] It is to be noted that, although the cathode electrode **4** is coupled with the hanging member **30** here, a female screw may be provided in the frame plate **29** to couple the cathode electrode **4** with the frame plate **29**. Further, the upper frame **6** made up of the frame plate **29** and the hanging member **30** may be comprised of one disc member.

[0030] As shown in FIGS. **1** and **2**, the lower frame **7** is formed, for example, in disc shape with an external diameter of the order of 160 mm and a height of the order of 15 mm, and the insulation tube **2**, the permanent magnet **3**, and the like are mounted on this lower frame **7**. As a material constituting the lower frame **7**, for example, iron is cited. An extraction port **37** for extracting ions generated in the inner space **9** of the insulation tube **2** and emitted through a hollow portion of the anode electrode **5** is formed in the lower frame **7**.

[0031] Further, the lower frame **7** is provided with an extraction electrode **38** and an extraction electrode **39** on the edge of the extraction port **37** and below the lower frame **7**. By application of an extraction voltage to between the extraction electrodes **38** and **39**, ions generated in the inner space **9** of the insulation tube **2** are extracted from the insulation tube **2**.

[0032] It should be noted that in the frame plate **29** of the upper frame **6** and the lower frame **7**, a shaft **41** with male screws formed at both ends of its outer peripheral surface is inserted through an insertion hole **42** formed in the upper frame **6** and the lower frame **7**, and the male screw is hinged by cramping the nut **43** to couple the upper frame **6** and the lower frame **7**, so as to fix the insulation tube **2** to the upper frame **6** and the lower frame **7**. Therefore, by removal of the nut **43** from the shaft **41**, the upper frame **6** that hangs the cathode electrode **4**, the permanent magnets **3** and the insulation tube **2** can be lifted upward so that the ion source **1** can be readily disassembled. This allows the user to readily make cleaning and maintenance of the ion source **1**.

[0033] The ion source **1** configured as thus described can be used for an accelerator **50** as in FIG. **7**. As shown in the figure, this accelerator **50** includes: a vacuum container **52** connected with a vacuum pump **51**; an acceleration tube **54** provided in a standing condition through a stage member **53** on the vacuum container **52**; and an ion generating device **55** provided in the upper portion of the acceleration tube **54**.

[0034] The acceleration tube **54** applies an acceleration voltage V to accelerate ions I emitted from the ion source **1** of the ion generating device **55**, and includes a plurality of acceleration electrodes **56** and a plurality of terminal bolts **57**. The acceleration electrode **56** is formed in an annular shape so as to be in intimate contact with the inner peripheral surface of the acceleration tube main body **58**, and the plurality of acceleration electrodes **56** are provided to be arranged in a row in the axial direction of the acceleration tube main body **58** at prescribed intervals. A male screw of the terminal bolt **57** is hinged from the outside into each bolt hole formed so as to penetrate through the acceleration tube main body **58** in its diameter direction, and the tip end of the terminal bolt **57** is in contact with the acceleration electrode **56** so that terminal bolt **57** and the acceleration electrode **56** are electrically connected to each other. Further, a voltage dividing resistor (not shown) is provided among each of the terminal bolts **57**, and when the acceleration voltage V is applied to between the uppermost acceleration electrode **56** and the lowermost acceleration electrode **56**, the acceleration voltage V is divided by a plurality of voltage dividing resistors to the acceleration electrodes **56**. It is to be noted that the lower frame **7** of the ion source **1** is fixed to the acceleration tube main body **58** by means of the bolt **59**.

[0035] Other than the above-mentioned ion source **1**, the ion generating device **55** includes a gas cylinder **60** which supplies the ion source **1** with gas for discharge, a first box-shaped insulating member **61**, a second box-shaped insulating member **62**, an insulating lid member **63**, an inverse box-shaped insulating member **64**, and a direct current power source (not shown).

[0036] The first box-shaped insulating member **61** is a box-shaped member opened upward. An insertion member **65**, formed in cylindrical shape for insertion therethrough of a power supply line for supplying power from the direct current power source to the ion source **1** and a variety of control lines, is joined to the bottom of the first box-shaped insulating member **61**. The second box-shaped insulating member **62** is a box-shaped member opened upward, which is housed inside the first box-shaped insulating member **61** and whose side walls and bottom are spaced by a prescribed distance from the side walls and the bottom of the first box-shaped insulating member **61** adjacent to the outside. The insulating lid member **63** is an insulating member in plate shape mounted on the upper ends of the side walls of the second box-shaped insulating member **62** so as to block the upper opening of the second box-shaped insulating member **62**. The inverse box-shaped insulating member **64** is an insulating member in inverse box shape opened downward such that each of its side walls is inserted into a space between each of the side walls of the two adjacent box-shaped insulating members, the first and second box-shaped insulating members **61** and **62**.

[0037] In a case of sputtering the solid material **18** to generate ions and accelerating the generated ions by means of the acceleration tube **54** in the ion source **1**, the user sets the ion source **1**, the direct current power source, the gas cylinder **60**, and the like in a state where the second box-shaped insulating member **62** is opened upward.

[0038] First, the user removes the bolt **33** and lifts the hanging member **30** of the upper frame **6** upward, to take out the cathode electrode **4** from the insulation tube **2**. Here, in the case of using a conductive material as the solid material **18** for a material intended to be obtained by sputtering, as shown in FIG. **5**, a conductive solid material **18***a* (**18**) with its cross section molded in substantially T-shape is inserted into a fitting unit **19***a* (**19**) of the cathode electrode **4** and fixed by means of a bolt **67**.

[0039] On the other hand, in the case of using an insulating material as the solid material **18** for the material intended to be obtained by sputtering, as shown in FIG. **6**, an insulating solid material **18***b* (**18**) is fixed to a fitting unit **19***b* (**19**) of the cathode electrode **4** by means of a pin having conductive properties (conductive pin **68**), for example made of Al. As shown in the figure, the conductive pin **68** with its horizontal portion having an area smaller than the area in the horizontal direction of the solid material and with a vertical portion having a length larger than the height of the solid material **18***b* is employed. An insulation hole **69** is formed in the solid material **18***b* such that the vertical portion of the conductive pin **68** can be inserted therethrough, and the solid material **18***b* is fixed to the fitting unit **19***b* of the cathode electrode **4** by means of a bolt **71** in a state where a tip end **70** of the vertical portion of the conductive pin **68** projected from the upper surface of the solid material **18***b* is electrically connected with the cathode electrode **4**. Here, as the insulating solid material **18***b* to be used, for example, BN, S_3N_4, BC, AIN, and the like can be cited.

[0040] As thus described, after the conductive or insulating solid material **18** has been fixed to the tip end of the cathode electrode **4**, the hanging member **30** is mounted on the frame plate **29** while the cathode electrode **4** is inserted into the inner space **9** of the insulation tube **2**, and the frame plate **29** and the hanging member **30** are fixed to each other by means of the bolt **33**. Thereby, the inner space **9** of the insulation tube **2** where the cathode electrode **4** has been inserted is blocked.

[0041] After completion of the setting of the ion source **1**, the direct current power source, the gas cylinder **60** and the like, the user mounts the insulating lid member **63** on the upper ends of the side walls of the second box-shaped insulating member **62**, and further inserts each of the side walls of the inverse box-shaped insulating member **64** into between each of the side walls of the first box-shaped insulating member **61** and the second box-shaped insulating member **62** to mount the inverse box-shaped insulating member **64** on the upper ends of the side walls of the first box-shaped insulating member **61**, so as to block the upper portion of the first box-shaped insulating member **61** and the second box-shaped insulating member **62**.

[0042] By operation of the vacuum pump **51** such as a rotary pump and a turbo pump, the inner space **9** of the insulation tube **2** and the inner space **75** of the acceleration tube main body **58**, communicating with the inside of the vacuum container **52** through the communicating hole **73** provided in the stage member **53** and the communicating hole **74** provided in the vacuum container **52**, is reduced in pressure to come into a high vacuum state. Thereby, the inner space **75** of the acceleration tube main body **58** is reduced in pressure to the order of 10^{-7} Torr, and the inner space **9** of the insulation tube **2** is reduced in pressure to the order of 10^{-3} Torr since the extraction port **37** and the extraction electrode **38** provided in the lower frame **7** function as apertures.

[0043] As thus described, with the inner space **9** of the insulation tube **2** being reduced in pressure to come into a suitable vacuum state, when rare gas having a high sputtering rate, such as nitrogen (N) and argon (Ar), is supplied as gas for discharge from the gas cylinder **60** to the inner space **9** of the insulation tube **2**, and a prescribed high voltage (e.g. the order of 3 kV) is applied from the direct current power source to between the anode electrode **5** and the cathode electrode **4**, the supplied gas for discharge is discharged between the anode electrode **5** and the cathode electrode **4**, to generate positive ions of the gas for discharge. When a conductive material is used as the solid material **18**, the generated positive ions of the gas for discharge are concentrated on the central axis due to the magnetic field in the axial direction generated by the permanent magnet **3**, and collide with the solid material **18***a* at the tip end of the cathode electrode **4** to which a negative voltage has been applied, and by sputtering, particles of the solid material **18***a* are sputtered from the surface of the solid material **18***a*.

[0044] It is to be noted that in the case of using an insulating material as the solid material **18**, as shown in FIG. **9**, part of the positive ions of the gas for discharge having collided with the surface of the conductive pin **68** collides with the surface of the solid material **18***b*, and particles of the solid material **18***b* are sputtered by sputtering. For example, in the case of using a conductive pin **68** made of aluminum (Al) and the solid material **18***b* made of boron nitride (BN), ions of nitrogen (N), boric acid (B) and aluminum (AL) can be generated.

[0045] As thus described, the ions I sputtered from the surface of the solid material **18** by sputtering of positive ions of the gas for discharge are extracted from the inner space **9** of the insulation tube **2** to the inner space **75** of the acceleration tube main body **58** by an extraction voltage applied to between the extraction electrode **38** and the extraction electrode **39**, and emitted in the downward direction of the inner space **75** of the acceleration tube main body **58** so as to correspond to the central axis of the inner space **75**. It is to be noted that charged particles emitted from the ion source **1** are not restricted to the ions I, but electrons or the like can obviously be emitted.

[0046] Meanwhile, in the acceleration tube main body **58**, when an acceleration voltage is applied to between the uppermost acceleration electrode **56** and the lowermost acceleration electrode **56**, the ions I emitted from the ion source **1** are accelerated in multiple stages by a divided voltage of the acceleration voltage applied to each of the acceleration electrodes **56** in the inner space **75** of the acceleration tube main body **58** reduced in pressure to come into the high vacuum state. The accelerated ions I are separated by means of an E×B mass separator (Wien Filter) provided outside the figure which is connected to the acceleration tube **54**, and only necessary ions are extracted. The

extracted ions can be utilized for improvement in surfaces of a variety of materials, and the like.

[0047] While the ion source **1** according to the present embodiment can be used as a sputter-type ion source as thus described, ions may also be generated by the use of a material gas. Namely, the ion source **1** is capable of using either solid or air raw material as a raw material for generating ions.

[0048] In the case of using the material gas, a material resistant to sputtering, such as tungsten (W), is fixed to the fitting unit **19** of the cathode electrode **4** in place of the solid material **18**. The material gas is supplied to the inner space **9** of the insulation tube **2** along with the gas for discharge, and when a prescribed high voltage is applied from the direct current power source to between the anode electrode **5** and the cathode electrode **4**, the material gas is ionized by positive ions of the gas for discharge having been discharged. Ions of the material gas ionized in such a manner are extracted by the extraction voltage so that the ions of the material gas can be obtained.

INDUSTRIAL AVAILABILITY

[0049] The present invention is applicable to a sputter type ion source which generates ions by sputtering the surface of a solid material.

BRIEF DESCRIPTION OF DRAWINGS

[0050] FIG. **1** is a sectional view of an ion source according to an embodiment of the present invention.

[0051] FIG. **2** is an expanded sectional view of the lower surface of an insulation tube and its periphery.

[0052] FIG. **3** is a plan view of the ion source.

[0053] FIG. **4** is a sectional view showing an anode electrode and an electrode rod.

[0054] FIG. **5** is an explanatory view showing the condition of fixing a conductive solid material to a fitting unit of the cathode electrode.

[0055] FIG. **6** is an explanatory view showing the condition of fixing an insulating solid material to the fitting unit of the cathode electrode.

[0056] FIG. **7** is a sectional view showing an accelerator for which the ion source according to the embodiment of the present invention.

[0057] FIG. **8** is an explanatory view showing the condition of ions being emitted from the ion source.

[0058] FIG. **9** is an explanatory view schematically showing the condition of particles of the insulating solid material being sputtered from its surface by sputtering.

BRIEF EXPLANATION OF THE DRAWINGS

[0059] **1** Ion source

[0060] **2** Insulation tube

[0061] **3** Permanent magnet (Magnetic field generating means)

[0062] **4** Cathode electrode

[0063] **5** Anode electrode

[0064] **6** Upper frame

[0065] **7** Lower frame

[0066] **8** Lower surface

[0067] **9** Inner space

[0068] **13** Handle

[0069] **18** Solid material

[0070] **19** Fitting unit

[0071] **20** Gas feeding-in hole (Gas supplying means)

[0072] **23** Opening

[0073] **29** Frame plate

[0074] **30** Hanging member

[0075] **37** Extraction port

[0076] **41** Shaft

[0077] **42** Insertion hole

[0078] **43** Nut

[0079] **68** Conductive pin

1. An ion source, comprising:

a cylindrical insulation tube, opened upward and opened at part of its lower surface:

a magnetic field generating means, provided on the outer peripheral surface of said insulation tube;

a gas supplying means for supplying gas into said insulation tube;

a cathode electrode, at the tip end of which a fitting unit for fitting of a solid material thereto is formed, and which is arranged in the inner space of said insulation tube;

an annular anode electrode, which is fitted to an opening in the lower surface of said insulation tube, to emit at its center ions generated in the inner space of said insulation tube;

an upper frame, which blocks the upper portion of said insulation tube and suspends said cathode electrode so as to allow said fitting unit to approach said anode electrode; and

a lower frame, in which an extraction port is formed for extracting ions emitted from said anode electrode, and on which said insulation tube is mounted.

2. The ion source according to claim 1, wherein said magnetic field generating means are a plurality of hollow cylindrical permanent magnets provided on the outer peripheral surface of said insulation tube to be arranged in a row in the axial direction of said insulation tube.

3. The ion source according to claim 2, wherein a handle is fixed to the outer peripheral surface of said plurality of permanent magnets.

4. The ion source according to claim 1, wherein said gas supplying means is a gas feeding-in hole formed in said cathode electrode connected with a gas supply source.

5. The ion source according to claim 1, wherein said cathode electrode fixes an insulating solid material to a

fitting unit formed at its tip end by means of a pin which has conductive properties and is electrically connected with said fitting unit.

6. The ion source according to claim 1, wherein a shaft inserted through an insertion hole formed in said upper frame and lower frame is fixed by clamping to couple said upper frame and said lower frame so that said insulation tube is fixed to said upper frame and said lower frame.

7. The ion source according to claim 1, wherein said ion source is used as an ion source of an ion implanting device.

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