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

(11) Publication number: **0 469 631 A2**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **91113057.3**

(51) Int. Cl.5: **H01J 41/14**

(22) Date of filing: **02.08.91**

(30) Priority: **03.08.90 JP 205224/90**

(43) Date of publication of application:
05.02.92 Bulletin 92/06

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB GR IT LI LU NL SE

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(54) Ion pump and vacuum pumping unit using the same.

(57) An exhaust apparatus and a vacuum pumping unit using the exhaust apparatus are disclosed. The exhaust apparatus comprises a thermionic emission source, an electron accelerating grid surrounding the thermionic emission source, an outer electrode surrounding the electron accelerating grid, an ion accelerating grid intersecting an axis of the outer electrode and installed apart from the outer electrode, a vessel containing the thermionic emission source, the electron accelerating grid, the outer electrode, and the ion accelerating grid therein, a magnet disposed outside of the vessel and generating a magnetic field almost parallel to the axis of the outer electrode, a power supply for heating the thermionic emission source, a first DC power supply for applying a voltage between the electron accelerating grid, the outer electrode and the thermionic emission source, a second DC power supply for applying a voltage between the outer electrode and the ion accelerating grid so as to get the outer electrode positive. The vacuum pumping unit is constituted by interposing the exhaust apparatus between a vacuum vessel to be evacuated and an auxiliary vacuum pump. By this, gas molecules in the vacuum vessel are ionized by electron bombardment and accelerated toward the auxiliary vacuum pump to be exhausted.

EP 0 469 631 A2

The present invention relates to an exhaust apparatus and a vacuum pumping unit including the exhaust apparatus, which are specifically adapted for discharging a gas in a vacuum vessel to produce an ultrahigh vacuum in the semiconductor process or the like.

Fig. 3 conceptionally illustrates a prior art vacuum equipment including the high vacuum pump, wherein a vacuum chamber 1 is connected to a vacuum pump 2 through an exhaust pipe 3. The vacuum pump 2, which comprises, for example, a turbo molecular pump, an oil diffusion pump, an ion pump and the like and, exhausts only the gas molecules which fly into the exhaust pipe 3 from the vacuum chamber 1.

However, in the above-constructed vacuum equipment, when a turbo molecular pump is used to exhaust a gas with a low compression ratio such as hydrogen, helium or the like, gas molecules may diffuse back to a high vacuum side i.e. to the vacuum chamber 1 and, thus causes a decrease in vacuum level.

In the case of an oil diffusion pump, the gas molecules, which were once exhausted by the pump, may flow back into the vacuum chamber and further, the vapor of pumping oil heated also diffuses back. Thus vacuum level decreases.

In the case of the ion pump, gas molecules absorbed into a titanium wall of the pump are desorbed and flow back into the vacuum chamber, thus reducing a vacuum level.

In the prior art, no effective means were available against the back diffusion of gas molecules with a low compression ratio or desorbed gas molecules from the vacuum pump. Nevertheless, oil vapor of the oil diffusion pump may be prevented only by providing a cold trap with liquid nitrogen, however, complete prevention for any counterflow has been substantially difficult.

The present invention has been carried out in view of the above circumstances, and its object is to provide an exhaust apparatus capable of obtaining a high degree of vacuum by exhausting gas molecules in the vacuum chamber through ionization and acceleration of the gas molecules.

Then, another object of the present invention is to provide a vacuum pumping unit for an exhaust apparatus which is combined with an auxiliary pump set on a back pressure side for the pumping unit. The vacuum pumping unit is capable of producing a high degree of vacuum by ionization and acceleration of the gas molecules in a vacuum chamber toward the auxiliary pump, and also by ionization and acceleration of gas molecules which flow back from the auxiliary pump toward the auxiliary pump.

The above object of the present invention is attained by an exhaust apparatus comprising a thermionic emission source, an electron accelerating grid surrounding the thermionic emission source, an outer electrode surrounding the electron accelerating grid, an ion accelerating grid intersecting an axis of the outer electrode and installed apart from the outer electrode, a vessel for containing said thermionic emission source, said electron accelerating grid, said outer electrode, and said ion accelerating grid therein, a magnet disposed outside of the vessel to generate a magnetic field almost parallel to the axis of said outer electrode, a power supply for heating said thermionic emission source, a first DC power supply for applying a voltage between said electron accelerating grid, said outer electrode and said thermionic emission source, a second DC power supply for applying a voltage between said outer electrode and said ion accelerating grid so as to get said outer electrode positive.

Further, the above object of the present invention is attained by an exhaust apparatus comprising a thermionic emission source, an outer electrode surrounding the thermionic emission source, an ion accelerating grid intersecting an axis of the outer electrode and installed apart from the outer electrode, a vessel for containing said thermionic emission source, said outer electrode, and said ion accelerating grid therein, a magnet disposed outside of the vessel for generating a magnetic field almost parallel with the axis of said outer electrode, a power supply for heating said thermionic emission source, a first DC power supply for applying a voltage between said outer electrode and said thermionic emission source, a second DC power source for applying a voltage between said outer electrode and said ion accelerating grid so as to get said outer electrode positive.

Then, the other object of the present invention is attained by a vacuum pumping unit including an arbitrary vacuum pump and an exhaust apparatus, in which said exhaust apparatus comprises a thermionic emission source, an electron accelerating grid surrounding the thermionic emission source, an outer electrode surrounding the electron accelerating grid, an ion accelerating grid intersecting an axis of the outer electrode and installed apart from the outer electrode, a vessel containing said thermionic emission source, said electron accelerating grid, said outer electrode, and said ion accelerating grid therein, a magnet disposed outside of the vessel and generating a magnetic field almost parallel to the axis of said outer electrode, a power supply for heating said thermionic emission source, a first DC power supply for applying a voltage between said electron accelerating grid, said outer electrode and said thermionic emission source, a second DC power supply for applying a voltage between said outer electrode and said ion accel-

erating grid so as to get said outer electrode positive are comprised, is interposed between said vacuum pump and a vacuum vessel to be evacuated.

Further, the other object of the present invention is attained by a vacuum pumping unit including an arbitrary vacuum pump and an exhaust apparatus, in which a thermionic emission source, an outer electrode surrounding the thermionic emission source, an ion accelerating grid intersecting an axis of the outer electrode and installed apart from the outer electrode, a vessel for containing said thermionic emission source, said outer electrode, and said ion accelerating grid therein, a magnet disposed outside of the vessel and generating a magnetic field almost parallel to the axis of said outer electrode, a power supply for heating said thermionic emission source, a first DC power supply for impressing a voltage between said outer electrode and said thermionic emission source, a second DC power supply for applying a voltage between said outer electrode and said ion accelerating grid so as to get said outer electrode positive are comprised, and which is interposed between said vacuum pump and a vacuum vessel to be evacuated.

According to the exhaust apparatus and the vacuum pumping unit of the present invention, since gas molecules are ionized by electron bombardment and are accelerated toward the auxiliary pump, the backflow of gas molecules from an auxiliary vacuum pump can be completely prevented to thereby realize a high degree of vacuum.

The features and advantages for the present invention will become more apparent from the following description in conjunction with figures for illustrative examples.

Fig. 1 is a block diagram for a vacuum pumping unit including an exhaust apparatus according to a one embodiment of the present invention;

Fig. 2 is a block diagram for another embodiment of the present invention;

and Fig. 3 is a drawing for conceptionally illustrating a prior art vacuum exhaust equipment.

In Figure 1, a reference number 50 denotes an exhaust apparatus according to the present invention, and 100 denotes a vacuum pumping unit, the vacuum pumping unit 100 comprising a combination of the exhaust apparatus 50 with an arbitrary vacuum pump 31 provided on a back pressure side of the exhaust apparatus 50.

The exhaust apparatus 50 comprises a hairpin shaped thermionic emission filament 21 as a thermionic emission source, a cylindrical electron accelerating grid 22, a cylindrical outer electrode 23, an ion accelerating flat grid 24, a vessel 25, an electromagnet 26, a power supply 28 for heating the filament 21, an electron accelerating DC power supply 29, and an ion accelerating DC power supply 30, and the exhaust apparatus is interposed between a vacuum vessel 32 to be evacuated and the vacuum pump 31 which operates as an auxiliary pump.

The thermionic emission filament 21, the electron accelerating grid 22, the outer electrode 23, and the ion accelerating grid 24 are each disposed within the vessel 25.

The filament 21 is disposed nearly at the center of the vessel 25, and is also disposed along a longitudinal axis of the vessel.

The electron accelerating grid 22 is disposed surrounding the filament 21, and the outer electrode 23 is disposed surrounding the electron accelerating grid 22.

Then, the ion accelerating grid 24 intersects an axis of the outer electrode 23 perpendicularly and is disposed on the vacuum pump 31 side apart somewhat from the outer electrode 23.

The electromagnet 26, the power supply 28, the electron accelerating DC power supply 29, and the ion accelerating DC power supply 30 are disposed out of the vessel 25, and the electromagnet 26 disposed along a peripheral portion of the vessel 25 generates a DC magnetic field almost parallel with the axis of the outer electrode 23 in the vessel 25.

The DC power supply 29 is connected between the filament 21, the electron accelerating grid 22 and the outer electrode 23, and applies a voltage so as to get the filament 21 in negative potential.

The ion accelerating DC power supply 30 is connected between the electron accelerating grid 22, the outer electrode 23 and the ion accelerating grid 24, which applied a voltage so as to get the outer electrode 23 in positive potential.

Then, a current and a voltage from the power supplies 28, 29, 30 are applied to the above-mentioned elements 21, 22, 23 and 24 through current leading-in terminals (not indicated) provided on a part of the vessel 25.

When the filament 21 is heated by the power supply 28, the filament 21 emits thermal electrons. The emitted electrons are accelerated toward the electron accelerating grid 22, and obtain a sufficient energy. Then they pass through the electron accelerating grid 22. A magnetic field which orthogonally crosses the direction of the electrons movement is applied by the electromagnet 26 within a space between the electron accelerating grid 22 and the outer electrode 23, and thus the electrons move in a circular motion within the plane perpendicular to an axis of the outer electrode 23 while moving toward the outer electrode 23. Due to the circular motion of the electrons, a path of the electrons to reach the outer electrode 23 becomes longer, and thus the electrons easily come to col-

lide with a lot of gas molecules and produce a large quantity of ions. The produced ions are accelerated toward the ion accelerating grid 24, and exhausted through the pump 31.

On the other hand, the gas molecules flowing back or desorbed from the vacuum pump 31 toward a high vacuum side are ionized and accelerated likewise in the manner stated above by the exhaust apparatus 50 and returned to the vacuum pump 31, therefore a high vacuum level is attained in the vacuum vessel.

In the prior art, when an evacuation is carried out only by the vacuum pump 31, only gas molecules coming into the exhaust pipe are exhausted. However, since the gas molecules are ionized and accelerated for exhaust by the above-mentioned operation of the invention, an exhaust efficiency is increased and a high vacuum level is obtained.

Fig. 2 represents an exhaust apparatus and a vacuum pumping unit according to another embodiment of the present invention.

The embodiment comprises a structure almost same as the embodiment shown in Fig. 1. As the same reference numbers represent the same constituents and operation in Fig. 1 and Fig. 2, repetitious descriptions will be omitted here.

In Fig. 2, a reference number 60 denotes an exhaust apparatus, 110 denotes a vacuum pumping unit which operates on the exhaust apparatus 60. The vacuum pumping unit 110 consists of the exhaust apparatus 60 and the arbitrary vacuum pump 31 provided on a back pressure side of the exhaust apparatus 60.

In the exhaust apparatus 60 of this embodiment, the electron accelerating grid 22 in Fig. 1 is omitted. That is, the exhaust apparatus 60 has only the hairpin shaped thermionic emission filament 21 as a thermionic emission source and the outer electrode 23 surrounding the filament 21 concentrically disposed within the vessel 25.

In Fig. 2, thermal electrons emitted from the heated filament 21 are attracted toward the outer electrode 23, and make a circular orbit under the magnetic field generated by the electromagnet 26. As the electrons run on a long path because of the circular orbit until the reach of the electrode 23, they collide with a lot of gas molecules to produce a large quantity of ions. The produced ions are accelerated toward the ion accelerating grid 24 and are exhausted by the pump 31. As a result, the gas molecules are exhausted by the vacuum pump 31 operating as an auxiliary exhaust means.

Thus, the present embodiment has a difference partly in construction and operation from the embodiment of Fig. 1, but, an exhaust effect is same.

As described above, according to the exhaust apparatus and the vacuum pumping unit of the present invention, ionization and acceleration of gas molecules which come in the vessel 25 by diffusion from the vessel 32 to be evacuated and by back diffusion from an auxiliary vacuum pump 31 can realize a high degree of vacuum.

Claims

1. An exhaust apparatus comprising a thermionic emission source, an electron accelerating grid surrounding the thermionic emission source, an outer electrode surrounding the electron accelerating grid, an ion accelerating grid intersecting an axis of the outer electrode and installed apart from the outer electrode, a vessel for containing said thermionic emission source, said electron accelerating grid, said outer electrode, and said ion accelerating grid therein, a magnet disposed outside of the vessel to generate a magnetic field almost parallel to the axis of said outer electrode, a power supply for heating said thermionic emission source, a first DC power supply for applying a voltage between said electron accelerating grid, said outer electrode and said thermionic emission source, a second DC power supply for applying a voltage between said outer electrode and said ion accelerating grid so as to get said outer electrode positive.

2. The exhaust apparatus claimed in claim 1, wherein said thermionic emission source is hairpin shaped thermionic emission filament.

3. The exhaust apparatus claimed in claim 1, wherein said thermionic emission source is disposed nearly at the center of said vessel, and is disposed along a longitudinal axis of said vessel.

4. The exhaust apparatus claimed in claim 1, wherein said ion accelerating grid intersects the axis of said outer electrode perpendicularly.

5. The exhaust apparatus claimed in claim 1, wherein said magnet is an electromagent disposed along an outer peripheral portion of said vessel.

6. The exhaust apparatus claimed in claim 1, wherein said second DC power supply is connected between said electron accelerating grid, said outer electrode and said ion accelerating grid.

7. The exhaust apparatus claimed in claim 1, wherein output from said heating power supply, said first DC power supply and said sec-

ond DC power supply are applied to said thermionic emission source, said electron accelerating grid, said outer electrode and said ion accelerating grid through terminals provided on said vessel.

8. An exhaust apparatus comprising a thermionic emission source, an outer electrode surrounding the thermionic emission source, an ion accelerating grid intersecting an axis of the outer electrode and installed apart from the outer electrode, a vessel for containing said thermionic emission source, said outer electrode, and said ion accelerating grid therein, a magnet disposed outside of the vessel for generating a magnetic field almost parallel with the axis of said outer electrode, a power supply for heating said thermionic emission source, a first DC power supply for applying a voltage between said outer electrode and said thermionic emission source, a second DC power source for applying a voltage between said outer electrode and said ion accelerating grid so as to get said outer electrode positive.

9. The exhaust apparatus claimed in claim 8, wherein said thermionic emission source is a hairpin shaped thermionic emission thermionic emission source.

10. The exhaust apparatus claimed in claim 8, wherein said filament is disposed nearly at the center of said vessel, and is disposed along a longitudinal axis of said vessel.

11. The exhaust apparatus claimed in claim 8, wherein said ion accelerating grid intersects the axis of said outer electrode perpendicularly.

12. The exhaust apparatus claimed in claim 8, wherein said magnet is an electromagnet disposed along an outer peripheral portion of said vessel.

13. The exhaust apparatus claimed in claim 8, wherein output from said heating power supply, said first DC power supply and said second DC power supply are applied to said thermionic emission source, said outer electrode and said ion accelerating grid through terminals provided on said vessel.

14. A vacuum pumping unit including an arbitrary vacuum pump and an exhaust apparatus, in which said exhaust apparatus comprises a thermionic emission source, an electron accelerating grid surrounding the thermionic emission source, an outer electrode surrounding the electron accelerating grid, an ion accelerating grid intersecting an axis of the outer electrode and installed apart from the outer electrode, a vessel containing said thermionic emission source, said electron accelerating grid, said outer electrode, and said ion accelerating grid therein, a magnet disposed outside of the vessel and generating a magnetic field almost parallel to the axis of said outer electrode, a power supply for heating said thermionic emission source, a first DC power supply for applying a voltage between said electron accelerating grid, said outer electrode and said thermionic emission source, a second DC power supply for applying a voltage between said outer electrode and said ion accelerating grid so as to get said outer electrode positive are comprised, is interposed between said vacuum pump and a vacuum vessel to be evacuated.

15. The vacuum pumping unit claimed in claim 14, wherein said thermionic emission source is a hairpin shaped thermionic emission source.

16. The vacuum pumping unit claimed in claim 14, wherein said thermionic emission source is disposed nearly at the center of said vessel, and is disposed along a longitudinal axis of said vessel.

17. The vacuum pumping unit claimed in claim 14, wherein said ion accelerating grid intersects the axis of said outer electrode perpendicularly.

18. The vacuum pumping unit claimed in claim 14, wherein said magnet is electromagnet disposed along an outer peripheral portion of said vessel.

19. The vacuum pumping unit claimed in claim 14, wherein said second DC power supply is connected between said electron accelerating grid, said outer electrode and said ion accelerating grid.

20. The vacuum pumping unit claimed in claim 14, wherein output from said heating power supply, said first DC power supply and said second DC power supply are applied to said thermionic emission source, said electron accelerating grid, said outer electrode and said ion accelerating grid through terminals provided on said vessel.

21. A vacuum pumping unit including an arbitrary vacuum pump and an exhaust apparatus, in

which a thermionic emission source, an outer electrode surrounding the thermionic emission source, an ion accelerating grid intersecting an axis of the outer electrode and installed apart from the outer electrode, a vessel for containing said thermionic emission source, said outer electrode, and said ion accelerating grid therein, a magnet disposed outside of the vessel and generating a magnetic field almost parallel to the axis of said outer electrode, a power supply for heating said thermionic emission source, a first DC power supply for impressing a voltage between said outer electrode and said thermionic emission source, a second DC power supply for applying a voltage between said outer electrode and said ion accelerating grid so as to get said outer electrode positive are comprised, and which is interposed between said vacuum pump and a vacuum vessel to be evacuated.

22. The vacuum pumping unit claimed in claim 22, wherein said thermionic emission source is a hairpin shaped thermionic emission source.

23. The vacuum pumping unit claimed in claim 22, wherein said thermionic emission source is disposed nearly at the center of said vessel, and is disposed along a longitudinal axis of said vessel.

24. The vacuum pumping unit claimed in claim 22, wherein said ion accelerating grid intersects the axis of said outer electrode perpendicularly.

25. The vacuum pumping unit claimed in claim 22, wherein said magnet is an electromagnet disposed along peripheral portion of said vessel.

26. The vacuum pumping unit claimed in claim 22, wherein output from said heating power supply, said first DC power supply and said second DC power supply are applied to said thermionic emission source, said electron accelerating grid, said outer electrode and said ion accelerating grid through terminals provided on said vessel.

Fig. 1

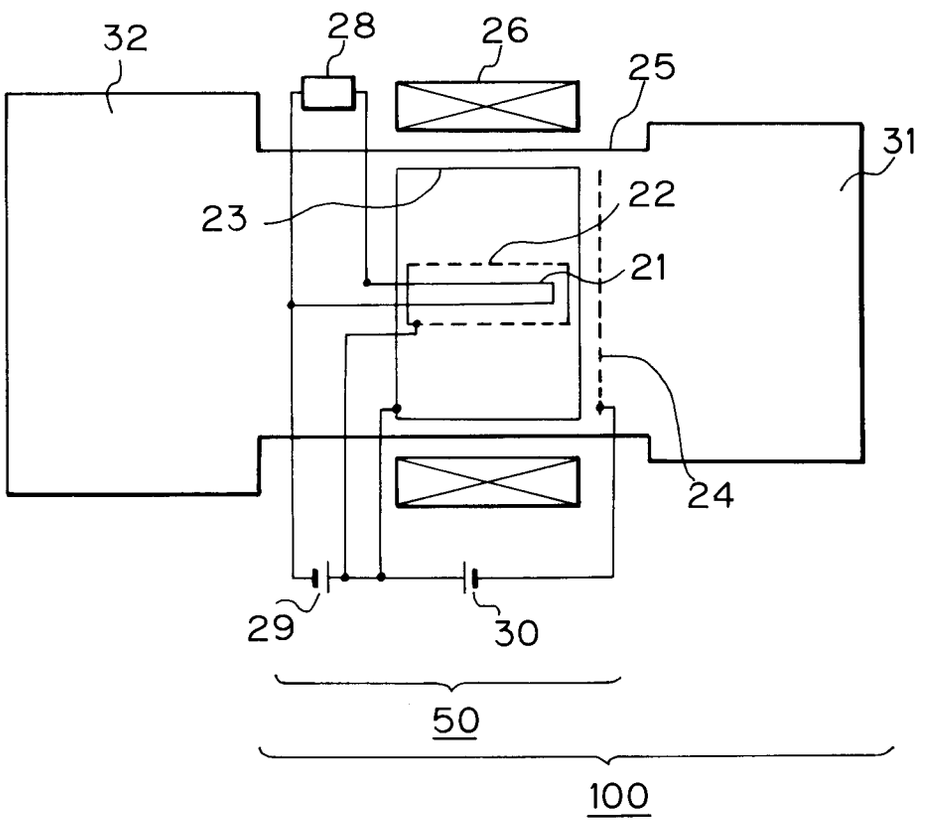

Fig. 2

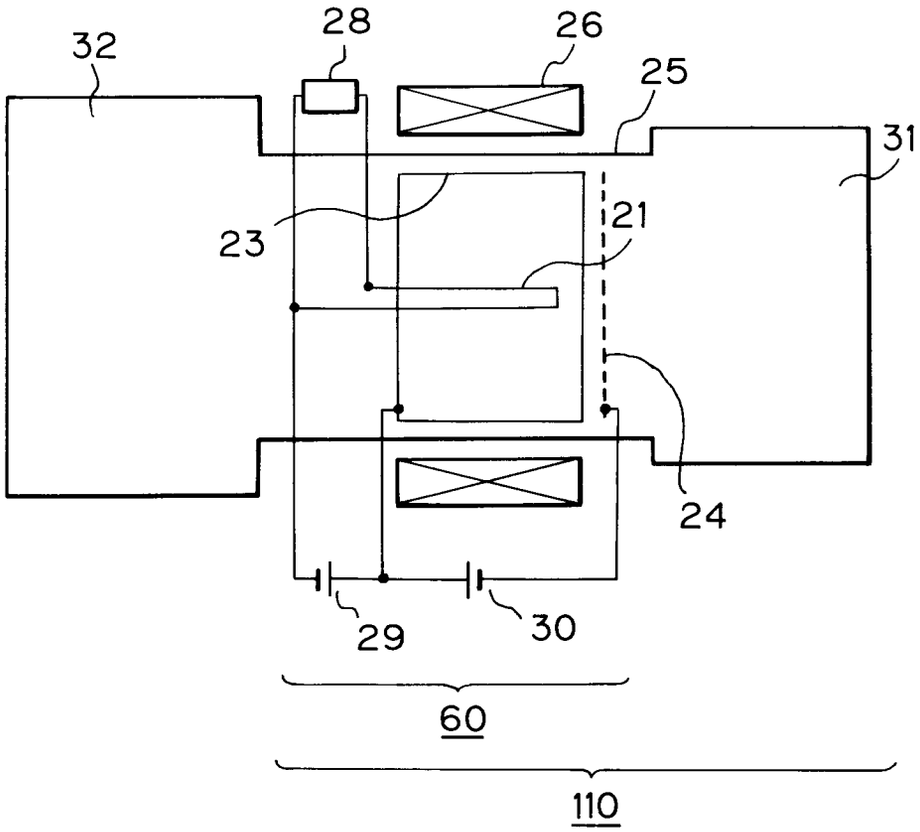

Fig. 3