

## SPECIFICATION

## VALVE UNIT AND HEAT TREATMENT SYSTEM

## 5 TECHNICAL FIELD

The present invention relates to a heat treatment system, and more particularly to a valve unit suitably used in an exhaust system of the heat treatment system, and a heat treatment system including the valve unit.

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## BACKGROUND ART

In manufacturing of a semiconductor device, a heat treatment system is used for performing a heat treatment such as a CVD (Chemical Vapor Deposition) treatment to a process object such as a semiconductor wafer. The heat treatment system includes a heat treatment furnace for containing wafers therein, a gas supply system for supplying a gas such as a process gas into the heat treatment furnace, and an exhaust system for sucking the interior of the heat treatment furnace to create an atmosphere of a reduced pressure.

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In evacuating the heat treatment furnace, a so-called slow vacuuming in which the discharge rate is kept low is carried out at an early vacuuming stage, in order to prevent raising particles. To this end, the exhaust system is configured as shown in Fig. 6. The exhaust system 12 includes a pipe 13 of a predetermined diameter of, e.g., 3 inches. The pipe 13 is provided with a main valve (main open-close valve) 18 in a form of an angle valve, a main pressure control valve (not shown) in a form of a butterfly valve, and a vacuum pump (not shown), which are sequentially arranged.

25 The exhaust system 12 includes a pipe 13 of a predetermined diameter of, e.g., 3 inches. The pipe 13 is provided with a main valve (main open-close valve) 18 in a form of an angle valve, a main pressure control valve (not shown) in a form of a butterfly valve, and a vacuum pump (not shown), which are sequentially arranged.

30 Bypass pipes 60, each having a small diameter such as about 1/4 inches, are connected to the pipe 13 to bypass the main valve 18. The bypass pipes 60 are provided with a first auxiliary valve 61 and a second auxiliary valve 62 arranged in parallel with each other. A needle valve 63 for flow control is arranged in series with the

35 second auxiliary valve 62 on one bypass pipe 60.

In order to reduce the pressure in the furnace from the

atmospheric pressure to a predetermined process pressure, at first, the main valve 18 and the first auxiliary valve 61 are closed while the second auxiliary valve 62 is opened, so as to carry out a slow vacuuming at a minute flow rate regulated by the needle valve 63.

5    Thereafter, the first auxiliary valve and the main valve are sequentially opened, and, under this condition, the furnace is evacuated until the pressure therein is reduced to a predetermined process pressure.

10    However, in the above conventional heat treatment system, since the bypass pipes 60 provided with the first and second auxiliary valves 61 and 62 is connected to the pipe 13, a wide space Sa (see Fig. 6 (b)) is required. In addition, the arrangement around the pipe 13 is complicated, which inhibits maintenance of the heat treatment system.

15    Further, in order for the main valve 18 to be fixed in place, the pipe 13 must be fixed on a housing 14 of the heat treatment system via a bracket 70 at a position upstream or downstream of the main valve 18. Thus, the arrangement around the pipe 13 is more complicated. In a case where the pipe 13 is a heated pipe, 20    heat is drawn from the pipe through the bracket 70, and thus reaction by-products are likely to be generated in the pipe 13.

#### SUMMARY OF THE INVENTION

25    The present invention is made in view of the above problems, and therefore an object of the present invention is to provide a simple, compact valve unit by integrating an auxiliary valve and bypass passages with a main valve. Another object of the present invention is to simplify a pipe arrangement in an exhaust system of a heat treatment system, by using such a 30    simple, compact valve unit.

35    In order to achieve the above objects, the present invention provides a heat treatment system comprising: a heat treatment furnace; an exhaust pipe connected to the heat treatment furnace to discharge an atmosphere in the heat treatment furnace; and a main valve mounted on the exhaust pipe, the main valve having a valve casing in which an inlet port,

an outlet port and a main passage connecting the inlet port and the outlet port are formed, and also having a valve element arranged in the valve casing to open and close the main passage, wherein: a first bypass passage and a second bypass  
5 passage are formed in parallel in the valve casing of the main valve, each of the bypass passages connecting the inlet port and the outlet port; and the valve casing of the main valve is provided with a first auxiliary valve adapted to open and close the first bypass passage and a second auxiliary valve adapted to  
10 open and close the second bypass passage.

In a preferred embodiment, the first and second bypass passages comprise holes formed in a wall member of the valve casing.

In a preferred embodiment, the second auxiliary valve  
15 has flow-adjustability.

In a preferred embodiment, the valve casing of the main valve is provided with a fixing member, and the main valve is fixed to a housing of said heat treatment system via the fixing member.

20 According to a second aspect of the present invention, there is provided a valve unit including a valve casing in which an inlet port, an outlet port and a main passage connecting the inlet port and the outlet port are formed, and also including a valve element arranged in the valve casing to open and close  
25 the main passage, wherein said valve unit further includes: a first bypass passage arranged in the valve casing and adapted to connect the inlet port and the outlet port while bypassing the valve element; a second bypass passage arranged in the valve casing in parallel with the first bypass passage and adapted to  
30 connect the inlet port and the outlet port while bypassing the valve element; a first auxiliary valve adapted to open and close the first bypass passage; and a second auxiliary valve adapted to open and close the second bypass passage.

Further features and advantages of the present invention  
35 will be more fully apparent from the following detailed description with accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 schematically shows the structure of a heat treatment system in one embodiment of the present invention;

5        Fig. 2 is a perspective view of the main valve shown in Fig. 1;

      Fig. 3 is a fragmentary sectional view of a principal part of the main valve shown in Fig. 2;

      Fig. 4 is an enlarged cross-sectional view of the second  
10       auxiliary valve shown in Fig. 2 taken along line IV-IV in Fig. 3;

      Fig. 5 shows an arrangement of component parts around the main valve, where (a) shows a side view and (b) shows a plan view; and

      Fig. 6 shows a conventional arrangement of component  
15       parts around the main valve, where (a) shows a side view and (b) shows a plan view.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

20       An embodiment of the present invention will be described with reference to the accompanying drawings.

      In Fig. 1 schematically showing the structure of a heat treatment system, the reference numeral 1 depicts a heat treatment furnace, which contains semiconductor wafers W and performs a heat treatment such as a CVD process. In the  
25       illustrated embodiment, the heat treatment furnace 1 is a batch-type vertical furnace. The heat treatment furnace 1 includes a processing vessel (reaction tube) 2 made of quartz, and a cylindrical heater 3 surrounding the processing vessel 2.

      Although the illustrated processing vessel 2 has a  
30       double-tube structure having an inner tube 2a and an outer tube 2b, the processing vessel may have a single-tube structure. A lower end of the processing vessel 2 is opened. A cylindrical manifold 6 is connected to the lower end of the processing vessel 2 in an air-tight fashion. The manifold 6 is provided with  
35       a gas inlet part 4 for receiving a gas such as a process gas into the processing vessel 2, and an exhaust part 5 for discharging

an atmosphere in the processing vessel 2. A lower end of the manifold 6 is opened to provide a furnace throat 7. A cover member 8 adapted to hermetically close the furnace throat 7 is arranged below the throat 7. The cover member 8 is vertically moved by an elevating mechanism 9 to open and close the furnace throat 7. A wafer boat 10 (i.e., a substrate holder) made of quartz, which is capable of holding a plurality of, e.g., 150 wafers at vertical intervals, is mounted on the cover member 8 through a heat-insulating tube 11. The wafer boat 10 is loaded and unloaded into and from the processing vessel 2 by means of the elevating mechanism 9.

A pipe included in a gas supply system (not shown) connected to a gas supply source is connected to the gas inlet part 4, and a pipe (referred to as an "exhaust pipe") 13 included in an exhaust system 12 is connected to the exhaust part 5. As shown in Fig. 5, the heat treatment furnace 1 is placed in a housing 14 of the heat treatment system. The housing 14 is provided with a base plate 15 having an opening through which the processing vessel 2 can be inserted into the housing 14 from below the base plate. The manifold 6 is attached to the base plate 15 via a bracket (not shown). The heater 3 is disposed on the base plate 15. Provided below the base plate 15 is a loading area serving as a work area for loading and unloading of the wafer boat 10

The pipe 13 of the exhaust system 12 extends from the interior the housing 14 to the exterior of the same, and is connected to a vacuum pump 17 arranged at a lower site. The pipe 13 of the exhaust system 12 is provided with a main valve 18 in a form of an angle valve, a pressure control valve 19 in a form of a butterfly valve, and a trap 20 for capturing by-products, which are arranged in that order from the upstream side. The exhaust system 12 is constituted by the pipe 13, and the main valve 18, the pressure control valve 19, the pressure reducing pump 17, and the trap 20 arranged on the pipe 13.

Referring to Figs. 2 to 4, the main valve 18 and the

associated mechanisms will be described. The main valve 18 includes a valve casing 21 (valve body), and a valve element 26 arranged in the valve casing 21. An inlet port 22 and an outlet port each adapted to flanged connection are arranged at the side and the bottom of the valve casing 21, respectively. As shown in Fig. 3, a main passage 24 is formed in the valve casing 21 to connect the inlet port 22 and the outlet port 23. A valve seat 25 is disposed in the main passage 24. When the main valve 18 is closed, the valve element 26 is seated on the valve seat 25.

An actuator 28 is disposed on an upper part of the valve casing 21. The actuator 28 vertically moves the valve element 26 through a valve rod 27 so as to open and close the main valve 18. The valve rod 27 is surrounded by a bellows 29. The upper end of the bellows 29 is connected to the valve casing 21, while the lower end of the bellows 29 is connected to the upper surface of the valve element 26. The bellows 29 protects the actuator 28 from a corrosive gas.

A first bypass passage 32 and a second bypass passage 33, which are separated from each other, are formed in parallel in the valve casing 21 of the main valve 18. The bypass passages 32 and 33 comprise holes formed in a wall member of the valve casing 21. Provided on the side surfaces of the valve casing 21 are a first auxiliary valve 30 for opening and closing the first bypass passage 32, and a second auxiliary valve 31 for opening and closing the second bypass passage 33. The first and second bypass passages 32 and 33 allow a fluid to flow from the inlet port 22 to the outlet port 23 without passing through a portion of the main passage 24 between the valve seat 25 and the valve element 26.

As shown in Fig. 3, an intermediate portion of the first bypass passage 32 is opened to the side surface of the valve casing 21. A part of the side surface of the valve casing 21 surrounding the openings of the first bypass passage 32 serves as a valve seat 34. The first auxiliary valve 30 includes a valve casing 36 attached to the side of the valve casing 21, and a

valve element 37 arranged in the valve casing 36. The valve element 37 is biased by a not-shown spring in the valve-closing direction (i.e., the direction in which the valve element 37 moves to be seated on the valve seat 34). A pipe 38 included in a pressurized air supply system is connected to the valve casing 36 to supply compressed air into the valve casing 36 for driving the valve element 37 in the valve-opening direction (i.e., the direction in which the valve element 37 moves away from the valve seat 34) against the biasing force of the spring.

When no compressed air is supplied into the valve casing 36, the valve element 37 of the first auxiliary valve 30 is seated on the valve seat 34 to close the first bypass passage 32. When compressed air is supplied into the valve casing 36, the valve element 37 of the first auxiliary valve 30 moves away from the valve seat 34 to open the first bypass passage 32.

As shown in Fig. 4, an intermediate portion of the second bypass passage 33 is opened to the side surface of the valve casing 21. A part of the side surface of the valve casing 21 surrounding the second bypass passage 33 serves as a valve seat 35. The second auxiliary valve 31 includes a valve casing 39 attached to the side part of the valve casing 21, and a valve element 41 arranged in the valve casing 39. The valve element 41 is biased by a spring 40 in the valve-closing direction (i.e., the direction in which the valve element 41 moves to be seated on the valve seat 35). A pipe 42 included in a pressurized air supply system is connected to the valve casing 39 to supply compressed air into the valve casing 39 for driving the valve element 41 in the valve-opening direction (i.e., the direction in which the valve element 41 moves away from the valve seat 35) against the biasing force of the spring 40. When no compressed air is supplied into the valve casing 39, the valve element 41 of the second auxiliary valve 31 is seated on the valve seat 35 to close the second bypass passage 33. When compressed air is supplied into the valve casing 39, the valve element 41 of the second auxiliary valve 31 moves away from the valve seat 35 to open the second bypass passage 33.

A piston 44 is connected to the valve element 41 through a valve rod 43. The piston 44 is slidably fitted in a cylinder 45 formed in the valve casing 39. The spring 40 for biasing the piston 44 in the valve-closing direction is embedded in one side of the cylinder 45. A pressure chamber 46 for driving the piston 44 in the valve-opening direction by compressed air is formed on the other side of the cylinder 45. An inlet passage 47 is formed in the piston 44 to supply compressed air, which is supplied through the pipe 42 of the pressurized air supply system, into the pressure chamber 46. The inlet passage 47 extends along an axis of the piston 44 and opens into the pressure chamber 46.

A flow-adjusting knob 48 is provided on an end portion of the valve casing 39 of the second auxiliary valve 31. An inner circumference of the flow-adjusting knob 48 is threaded, and is in thread-engagement with an external thread 49 formed on an outer circumference of the end portion of the valve casing 39. The flow-adjusting knob 48 has a sleeve 50 for restricting a moving range (i.e., an amount of lift of the valve element 41)  $\underline{d}$  of the piston 44. The sleeve 50 is disposed coaxially with the piston 44. A shaft part 51, which is an end part of the piston, 44 is slidably fitted in the sleeve 50. Thus, the lift amount  $\underline{d}$  of the valve element 41 can be varied by rotating the flow-adjusting knob 48, so that a flow rate of a fluid passing through the second bypass passage 33 can be adjusted.

The second auxiliary valve 31 is different from the first auxiliary valve 30 in that the former has a flow-adjustability while the latter provides a constant flow rate. The first auxiliary valve 30 can be constituted by omitting component parts of the second auxiliary valve 31 relating to the flow-adjusting function.

Referring again to Fig. 1, a pressure sensor 52 for detecting the pressure in the pipe 13 of the exhaust system 12 is disposed on the pipe 13 at a position upstream of the main valve 18. A detection signal of the pressure sensor 52 is input in a controller 53. The controller 53 controls opening and

closing operation of the main valve 18, the pressure control valve 19, the first auxiliary valve 30, and the second auxiliary valve 31, based on a prescribed control program to adjust the pressures in the exhaust system 12 and the heat treatment furnace 1.

The valve casing 21 of the main valve 18 has a fixing plate 54 through which the valve casing 21 of the main valve 18 is fixed to the housing 14 of the heat treatment system. The fixing plate 54 is attached to the valve casing 21 of the main valve 18 by suitable fixing means such as a screw 55. A hole 56 is formed in the fixing plate 54 to fix the fixing plate 54 to a suitable support member by a screw connection. For example, the main valve 18 can be securely fixed to the housing 14 of the heat treatment system, by attaching a bracket 57 to the housing 14 of the heat treatment system and then fixing the fixing plate 54 to the bracket 57 by means of a bolt and a nut, as shown in Fig. 5.

The operation of the heat treatment system will be described in a case where the pressure in the heat treatment furnace 1 is reduced from an atmospheric pressure to a predetermined process pressure. If rapid vacuuming (i.e., high-discharge-rate vacuuming) is carried out, it is possible that reaction by-products raises in the processing vessel and the semiconductor wafers W held by the wafer boat 10 are displaced. Thus, at first, the second auxiliary valve 31 is opened while the main valve 18 and the first auxiliary valve 30 are closed, and vacuum pump 17 is driven to start slow-vacuuming at minimal discharge rate. The discharge rate at this time can be set at a suitable value by means of the flow-adjusting knob 48. The atmosphere in the heat treatment furnace 1 is discharged through the exhaust pipe arranged at the exhaust part 5 of the manifold 6 and the pipe 13 of the exhaust system 12, and through the second bypass passage 33 of the main valve 18.

After the pressure in the heat treatment furnace 1 is reduced to a first reduced pressure, the first auxiliary valve 30 is opened to evaluate the furnace at an increased discharge rate

through the first and second bypass passages 32 and 33. After the pressure in the heat treatment furnace 1 is reduced to a second reduced pressure, the main valve 18 is opened to evacuate the furnace at a high discharge rate through the first  
5 and second bypass passages 32 and 33 and the main passage 24 of the main valve 18 until the pressure in the furnace is reduced to the final target pressure.

In the above embodiment, since the passages bypassing the main valve 18 are incorporated in the valve casing 21 of the  
10 main valve 18, there is no need to provide a pipe bypassing the main valve 18 which is separated from the pipe 13. As a result, the pipe arrangement of the exhaust system 12 can be simplified, resulting in space-saving and easy maintenance. Upon comparing the space Sb in Fig. 5B with the space Sa in Fig.  
15 6B, the space-saving effect is readily understood. Since the second auxiliary valve 31 has flow-adjustability, there is no need to provide an additional valve such as a needle valve having flow-adjustability. Accordingly, the structure of the exhaust system 12 can be further simplified.

20 Since the valve casing 21 of the main valve 18 can be fixed to the housing 14 of the heat treatment system via the fixing plate 54, it is not necessary to support the pipe 13 at positions upstream and downstream of the main valve 18 via brackets. Consequently, the arrangement of the pipe 13 and its surrounding can be further  
25 simplified. In addition, in a case where the pipe 13 is a heated pipe, heat is not drawn from the pipe due to the absence of bracket. As a result, generation of reaction by-products in the pipe is suppressed. In this point of view, it is preferable that the fixing plate 54 is arranged at a position remote from the main passage  
30 24 of the valve casing 21. In the illustrated embodiment, the fixing plate 54 is arranged near the actuator 28 to be spaced apart from the main passage 24.

Although a preferred embodiment of the present invention has been described with reference to the drawings, the present  
35 invention is not limited thereto, and various modifications are possible without departing from the scope of the invention. For

example, the heat treatment furnace is not limited to the vertical type, and may be a lateral type. Also, the heat treatment furnace is not limited to the batch type, and may be a single-wafer-processing type. The heat treatment is not limited to  
5 a CVD treatment, and may be an oxidation-, diffusion- or anneal-treatment. The process object is not limited to a semiconductor wafer, and may be a glass substrate, an LCD substrate, and so on.

## CLAIMS

1. A heat treatment system comprising:
  - a heat treatment furnace;
  - an exhaust pipe connected to the heat treatment furnace to discharge an atmosphere in the heat treatment furnace; and
  - a main valve mounted on the exhaust pipe, the main valve having a valve casing in which an inlet port, an outlet port and a main passage connecting the inlet port and the outlet port are formed, and also having a valve element arranged in the valve casing to open and close the main passage,wherein:
  - a first bypass passage and a second bypass passage are formed in parallel in the valve casing of the main valve, each of the bypass passages connecting the inlet port and the outlet port; and
  - the valve casing of the main valve is provided with a first auxiliary valve adapted to open and close the first bypass passage and a second auxiliary valve adapted to open and close the second bypass passage.
2. The heat treatment system according to claim 1, wherein the first and second bypass passages comprise holes formed in a wall member of the valve casing.
3. The heat treatment system according to claim 1, wherein the second auxiliary valve has flow-adjustability.
4. The heat treatment system according to claim 1, wherein the valve casing of the main valve is provided with a fixing member, and the main valve is fixed to a housing of said heat treatment system via the fixing member.
5. A valve unit including a valve casing in which an inlet port, an outlet port and a main passage connecting the inlet port and the outlet port are formed, and also including a valve

element arranged in the valve casing to open and close the main passage,

wherein said valve unit further includes:

a first bypass passage arranged in the valve casing and adapted to connect the inlet port and the outlet port while bypassing the valve element;

a second bypass passage arranged in the valve casing in parallel with the first bypass passage and adapted to connect the inlet port and the outlet port while bypassing the valve element;

a first auxiliary valve adapted to open and close the first bypass passage; and

a second auxiliary valve adapted to open and close the second bypass passage.

6. The valve unit according to claim 5, wherein the first and second bypass passages comprise holes formed in a wall member of the valve casing.

7. The valve unit according to claim 5, wherein the second auxiliary valve has flow-adjustability.

8. A heat treatment system comprising:

a heat treatment furnace;

an exhaust pipe connected to the heat treatment furnace to discharge an atmosphere in the heat treatment furnace; and

the valve unit, as defined in any one of claims 5 to 7, arranged in the exhaust pipe.