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Title of the invention:

PERFLUORIDE PROCESSING APPARATUS

Background of the Invention:

5           <Field of the Invention>

          The present invention relates generally to  
perfluoride processing apparatus and, more  
particularly, to perfluoride processing apparatus  
suitable for use during processing of perfluoride-  
10       carbon or perfluorocarbon (PFC) gases which generate in  
semiconductor fabrication processes and liquid crystal  
manufacturing processes or the like.

          <Prior Art>

          In the semiconductor fabrication and liquid  
15       crystal manufacturing processes, PFC gases are used as  
an etching gas of semiconductor and liquid crystal  
materials, a cleaning gas of etchers, and a cleaning  
gas of chemical vapor deposition (CVD) equipment.  
However, PFC gases are the ones that are extremely  
20       significant in anathermal coefficient to an extent  
that it is ten thousand to several thousand times  
greater than that of CO<sub>2</sub>. From a viewpoint of  
production efficiency without consumption of a total  
amount of PFC gas, the currently available  
25       semiconductor/liquid-crystal manufacturing processes

are designed so that after having consumed 20 to 50% of the gas, the remaining PFC gas is exhausted and drained out of an etcher (or CVD equipment) as an exhaust or waste gas. For the purpose of precluding anathermalization of the Earth, it is required to perform PFC gas decomposition processing to thereby prevent the PFC gas from being released to external environment. Note that representative examples of the PFC gas include, but not limited to,  $\text{CF}_4$ ,  $\text{CHF}_3$ ,  $\text{C}_2\text{F}_6$ ,  $\text{C}_3\text{F}_8$ ,  $\text{C}_4\text{F}_6$ ,  $\text{C}_5\text{F}_8$ ,  $\text{NF}_3$ , and  $\text{SF}_6$ .

In order to suppress outward release or emission of PFC gases to external environment, it has been known in semiconductor and liquid crystal manufacturing industries that as disclosed in Japanese Application Patent Laid-Open Publication No. Hei 11-319485, perfluocarbon decomposition devices (referred to as PFC decomposition devices hereinafter) are installed in units of PFC gas-use etchers so that each is adjacent to its associated etcher, wherein a catalyst is used to perform decomposition processing of a PFC gas in exhaust gases as drained out of the etchers. This PFC decomposition device is equipped with a reaction unit which is filled with a PFC decomposing catalyst, a silicon component removing device which removes silicon components contained in

an exhaust gas to be supplied to the reaction unit, a cooling chamber for cooling or refrigerating the exhaust gas that contains therein decomposition gas of the PFC as decomposed by the catalyst, and further an acidic gas removing device for removing an acidic gas contained in the exhaust gas as drained out of the cooling chamber. A catalyst-using PFC decomposition device is also disclosed in Japanese Application Patent Laid-Open Publication No. Hei 11-70322.

As the silicon component removing device, the cooling chamber and the acidic gas removing device require the use of water, it is a must to connect a water supply pipe to the individual PFC decomposition device. In view of the fact that each PFC decomposition device is installed within a clean room, respective water supply pipes being connected to them also are installed in the clean room. Water drain pipes also are connected to the PFC decomposition devices respectively. Due to this, part of the inner space of the clean room is to be occupied by the respective PFC decomposition devices and the water supply/drain pipes associated therewith. In case a clean room is newly formed with semiconductor fabrication apparatus (or alternatively liquid crystal manufacturing apparatus) such as a plurality of

etchers installed together therein, a need is felt to acquire within the clean room an installation space of a plurality of PFC decomposition devices and a variety of types of utility equipment (such as water supply  
5 pipes and water drain pipes or the like) associated therewith, which would result in the space within the clean room being enlarged accordingly. Alternatively, in the case of installation of one or more PFC decomposition devices within the currently established  
10 clean room, it sometimes happen that the semiconductor fabrication apparatus (or liquid crystal manufacturing apparatus) such as etchers which have been installed within the clean room must be moved in order to acquire the installation space of the PFC  
15 decomposition devices and various types of utility equipment.

Because of the installation of a variety of types of utility equipment with respect to each PFC decomposition device within the clean room, it takes  
20 much time to install these facilities.

#### Summary of the Invention:

It is therefore an object of the present invention to provide a perfluoride processing apparatus capable  
25 of relatively reducing the size of a clean room and

also a perfluoride processing method.

A principal feature of the present invention which attains the foregoing object lies in that it comprises an exhaust gas pipe connected to a plurality of  
5 semiconductor fabrication apparatuses installed within a clean room with perfluoride supplied thereto for permitting flow of an exhaust gas containing therein said perfluoride as drained out of the semiconductor fabrication apparatuses, and a perfluoride  
10 decomposition device connected to said exhaust gas pipe and installed outside of said clean room for decomposing said perfluoride as contained in said exhaust gas to be guided by said exhaust gas pipe.

In accordance with this invention, it is no longer  
15 required to acquire any extra space for installation of more than one perfluoride decomposition device within the clean room, which in turn makes it possible to reduce in size or "downsize" the clean room. In particular, in the case of application to the  
20 currently established clean room also, it is no longer necessary to acquire the installation space of such perfluoride decomposition device(s) within the clean room; thus, it makes it unnecessary to move the semiconductor fabrication apparatus within the clean  
25 room in order to perform installation of such

perfluoride decomposition device(s).

A principal feature of the present invention which is applied to liquid crystal manufacturing architectures lies in that it includes an exhaust gas pipe connected to a plurality of liquid crystal manufacturing apparatuses installed within a clean room with perfluoride supplied thereto for permitting flow of an exhaust gas containing therein said perfluoride as drained out of the liquid crystal manufacturing apparatuses, and a perfluoride decomposition device connected to said exhaust gas pipe and installed outside of said clean room for decomposing said perfluoride as contained in said exhaust gas to be guided by said exhaust gas pipe. In this case also, it is no longer required to acquire any extra space for installation of more than one perfluoride decomposition device within the clean room, which in turn makes it possible to downsize the clean room. Especially in the case of applying to the currently established clean room also, it is no longer necessary to acquire the installation space of such perfluoride decomposition device(s) within the clean room; thus, it makes it unnecessary to move the liquid crystal manufacturing apparatus within the clean room in order to perform the installation of such

perfluoride decomposition device(s).

Preferably the perfluoride decomposition device is equipped with a reaction unit in which a catalytic layer is provided and to which an exhaust gas  
5 containing perfluorides is supplied and which decomposes said perfluorides, and an acidic substance removing device which removes any reactive products as produced by chemical reaction with Ca salts of the acidic substance that is contained in the exhaust gas  
10 drained out of the reaction unit. The use of this perfluoride decomposition device causes the acidic substance being contained in the exhaust gas to be removed away as reactive products producible through reaction with Ca salts. Thus, no waste water generates  
15 from this perfluoride decomposition device.

#### Brief Description of the Drawings:

Fig. 1 is a diagram showing a configuration of PFC processing apparatus in accordance with one  
20 preferred embodiment of the present invention;

Fig. 2 is a diagram showing a detailed configuration of a wet-type PFC decomposition device of Fig. 1;

Fig. 3 is a configuration diagram of another  
25 embodiment of the wet-type PFC decomposition device;

Fig. 4 is a configuration diagram of still another embodiment of the wet-type PFC decomposition device;

Fig. 5 is a configuration diagram of a PFC processing apparatus in accordance with another  
5 embodiment of this invention;

Fig. 6 is a configuration diagram of a PFC processing apparatus which is another embodiment of the invention with a dry-type PFC decomposition device applied thereto;

10 Fig. 7 is a detailed configuration diagram of a filter device of Fig. 6;

Fig. 8 is a configuration diagram of another embodiment of the dry-type PFC decomposition device; and

15 Fig. 9 is a configuration diagram of a further embodiment of the dry-type PFC decomposition device.

#### Description of the Invention:

##### Embodiment 1

20 Prior to explanation of a perfluoride processing apparatus, that is, PFC processing apparatus, in accordance with one preferred embodiment of the present invention, a schematic configuration of a semiconductor fabrication system including a  
25 semiconductor fabrication factory will first be

explained with reference to Fig. 1 below. The illustrative semiconductor fabrication system is equipped with a semiconductor fabrication factory 1, a PFC decomposition device 44, and a factory acidic gas processing equipment 46. The building of semiconductor fabrication factory 1 has therein a clean room 2. A plurality of semiconductor fabrication apparatuses including etchers such as poly-etchers 3, an oxide film etcher 5, and a metal etcher 53 are installed within the clean room 2. Also installed within the clean room 2 is a plurality of gas supply devices 48. The individual gas supply device 48 is the one that supplies gases (such as PFC gas or the like) required at etching and cleaning process steps to its corresponding etcher (i.e. semiconductor fabrication apparatus with PFC gas supplied thereto). The gas supply device 48 is designed for example to internally have a build-in cylinder or "bomb" receiving vessel (not shown) in which a plurality of bombs (not shown) that are filled with required gases.

The factory acidic gas processing equipment 46 comprises an acidic gas removing device 47, a gas collection duct 49 and an exhaust duct 51. The gas collection duct 49 is for connection between the space within the bomb-receiving vessel and the acidic gas

removing device 47. The acidic gas removing device 47,  
which is installed out of the semiconductor  
fabrication factory building 1, is connected to the  
gas exhaust duct 51 through a blower 50. Depending  
5 upon the type of etcher, an acidic gas which is  
supplied from a bomb is used for wafer etching  
processes. When the acidic gas that is filled in the  
bomb leaks toward the outside by some causes, the  
bomb-receiving vessel is operable to prevent the  
10 leaked acidic gas from flowing into the clean room 2.  
Such leaked acidic gas as filled in the bomb-receiving  
vessel is driven by the blower 50 to reach the acidic  
gas removing device 47 through the gas collection duct  
49 and is then removed away at the acidic gas removing  
15 device 47. The remaining gas with the acidic gas  
removed away is drained out of an exhaust cylinder 52  
via the exhaust duct 51.

The PFC processing apparatus 44 comprises a duct 7,  
a PFC decomposition device 9 and a gas exhaust duct 28.  
20 The PFC decomposition device 9 is installed outside of  
the clean room 2 and within (or alternatively outside  
of) a little house (not shown) which is built within  
the site for the semiconductor fabrication factory at  
a location that is outside of the semiconductor  
25 fabrication factory building 1. The duct 7 is also

connected to the polyetchers 3, oxide film etcher 5 and metal etcher 53 respectively, which are installed within the clean room 2, and is also connected to the PFC decomposition device 9. An acid gas removing  
5 device 4 is installed at the duct 7 at a position adjacent to a connection portion with the polyetchers 3. Another acid gas removing device 4 is also installed at the duct 7 at a position adjacent to a connection portion with the metal etcher 53. A carbon  
10 monoxide removing device 6 is installed at the duct 7 at a position near a connection portion with the oxide film etcher 5. The exhaust duct 28 is connected to the PFC decomposition device 9 through a blower 25 and also to the exhaust gas cylinder 52.

15 A detailed configuration of the PFC decomposition device 9 will be explained based on Fig. 2. The PFC decomposition device 9 includes a pre-processing tower 10, a reactor 11, a cooling device 20, and an acidic gas removing device 22. The preprocessing tower 10 has  
20 a solid component removing device 54 and a neutralizing tank 61 which is provided at lower part of the solid component removing device 54. Sprays 62, 63 are installed within the solid component removing device 54. The reactor 11 has a heating unit 12 and a  
25 reacting unit 16. The heater unit 12 is equipped with

a heating device (for example, electric heater) 13 and forms a space 14 for use as a gas passage on the inner side of the heater device 13. The reaction unit 16 has a heating device (e.g. electric heater) 18 and a catalytic layer 17 as installed inside of the heater device 18. In the reaction unit 16, a space 19 for use as a gas passage is formed within the heater device 18 at a location overlying the catalyst layer 17. Upper part of the space 14 and upper part of the space 19 are coupled together by a duct 15. The cooler device 20 includes a spray 21 therein. Similarly the acidic gas removing device 22 also includes sprays 23, 24 therein.

The duct 7 is connected via a three-way valve 8 to the solid component removing device 54. One exhaust port of the three-way valve 8 is connected by a pipe 60 to the gas collection duct 49 at a location on the upstream side of the acidic gas removing device 47. The three-way valve 8 is an exhaust gas flow path changeover device which switches between the supplement of an exhaust gas to the solid component removing device 54 and the supplement to the pipe 60. The pipe 60 is a bypass pipe with respect to the PFC decomposition device 9. A pipe 26 connects together the solid component removing device 54 and the space

14 within the heater device 12. A space formed below the catalyst layer 17 within the reaction unit 16 is coupled by a pipe 27 to the cooler device 20. Upper part of the space within the cooler device 20 is  
5 coupled to the acidic gas removing device 22. The exhaust duct 28 is connected to the acidic gas removing device 22 at a location in on the upstream side of the blower 25. A water drain pipe 30 which is provided with a pump 29 is connected to a bottom  
10 portion of the cooler device 20. A pipe 31 that is connected to the water drain pipe 30 in the downstream of the pump 29 is connected to the spray 24. A pipe 32 connects the pipe 31 and the spray 21 together. A water drain pipe 37 in which a pump 36 is provided is  
15 connected to a bottom portion of the neutralizing tank 61. A pipe 38 which is connected to the water drain pipe 37 at a location in the downstream of a pump 36 is connected to the spray 63. A water supply pipe 33 is connected to the spray 23. The water supply pipe 34  
20 connects together the water supply pipe 33 and the spray 12. A water supply pipe 35 is coupled to the space 14 within the heating unit 12. An alkali tank 39 is connected to the neutralization tank 61 via a pipe 43 which is provided with a pump 42 and is also  
25 connected to the cooler device 20 by a pipe 40

provided with a pump 40.

Supplied to the polyetcher 3 from its associated gas supply device 48 are  $\text{Cl}_2$ ,  $\text{HBr}$ ,  $\text{CF}_4$  (in some cases,  $\text{CHF}_3$ ,  $\text{C}_5\text{F}_8$ ,  $\text{C}_2\text{F}_6$  or else).  $\text{CO}$ ,  $\text{CF}_4$  (in some cases,  $\text{CHF}_3$ ,  $\text{C}_5\text{F}_8$ ,  $\text{C}_2\text{F}_6$ ,  $\text{SF}_6$  or else) are supplied to the oxide etcher 5 from its associated gas supply device 48.  $\text{Cl}_2$ ,  $\text{BCl}_3$ ,  $\text{CF}_4$  (in some cases,  $\text{CHF}_3$ ,  $\text{C}_5\text{F}_8$ ,  $\text{C}_2\text{F}_6$  or else) are supplied to the metal etcher 53 from its associative gas supply device 48. Respective one of the above-noted gases are filled in separate bumps in corresponding gas supply devices 48 on a per-kind basis. Although part of each kind of gas as supplied to each etcher is consumed during wafer etching processes, the remaining gas will be drained out of each etcher as an exhaust or waste gas. Within each etcher,  $\text{HF}$  that is an acidic gas is produced by decomposition of PFC ( $\text{CF}_4$ ) thus consumed therein. In addition to the  $\text{HF}$ , the exhaust gas contains by-products ( $\text{SiF}_4$ ,  $\text{WF}_6$  and the like) as has been produced by reaction between wafer rare material as cut away through etching and the PFC gas(es) along with solid components ( $\text{SiO}_2$ ,  $\text{WO}_3$  and others).

After removal of harmful acid gas ( $\text{Cl}_2$ ) at the acid gas removing device 4, the exhaust gas as drained out of the polyetcher 3 is introduced into the solid

component removing device 54 via the duct 7. After  
removal of harmful gas (CO) at the carbon monoxide  
removing device 6, the exhaust gas drained out of the  
oxide film etcher 5 is introduced into the solid  
5 component removing device 54 via the duct 7. After  
removal of harmful acid gases ( $\text{Cl}_2$ ,  $\text{BCl}_3$ ) at the acid  
gas removing device 4, the exhaust gas drained out of  
the metal etcher 53 is introduced into the solid  
component removing device 54 via the duct 7. In cases  
10 where the PFC decomposition device 9 properly  
functions, the three-way valve 8 operatively couples  
together the etchers and the PFC decomposition device  
9 to thereby ensure that the exhaust gas drained out  
of each etcher can flow into the PFC decomposition  
15 device 9. Due to this, any exhaust gas cannot flow  
from the duct 7 into the pipe 60. The exhaust gas as  
drained out of an etcher which uses no harmful gases  
is directly drained out of this etcher to the duct 7.

Water which was supplied from the water supply  
20 pipe 34 is continuously sprayed from the spray 62 into  
the solid component removing device 54. The exhaust  
gas to be supplied to the solid component removing  
device 54 contains PFC ( $\text{CF}_4$ ) and also impurities which  
generate solid components by reaction with water such  
25 as  $\text{SiF}_4$  and  $\text{WF}_6$  or the like as produced during etching



be removed away by bubbling such exhaust gas into water in a water tank.

As has been described previously, the solid component removing device 54 is operable to remove not only the solid components ( $\text{SiO}_2$ ,  $\text{WO}_3$  and the like) contained in the exhaust gas being supplied thereto but also acidic gases ( $\text{SiF}_4$  and  $\text{WF}_6$  or else) which produce solid components by reaction with water. During removal of an acidic gas which purifies such solid components, the solid component removing device 54 also removes the solid components ( $\text{SiO}_2$ ,  $\text{WO}_3$  and the like) thus generated by reaction with water. Since these acidic gases are removed through reaction with water within the solid component removing device 54 at a pre-stage of the reactor 11, it is possible to avoid unwanted production of solid components ( $\text{SiO}_2$ ,  $\text{WO}_3$  and the like) within the reactor 11 by reaction between such acidic gases ( $\text{SiF}_4$  and  $\text{WF}_6$  or else) and reactive water as supplied to the space 14. Thus it is possible to solve the problems due to production of solid components ( $\text{SiO}_2$ ,  $\text{WO}_3$  and the like) within the reactor 11—that is, (1) solid components badly behave to block porous components as formed at a catalyst, and (2) solid components block gaps to be formed between the catalyst. Whereby the catalyst which comes into

contact with the exhaust gas does not decrease in surface area so that the PFC decomposition efficiency is improved.

The alkali water solution (e.g. sodium hydrate solution) within the alkali tank 39 is driven by the pump 42 to be supplied to the neutralization tank 61 through the pipe 43. The alkali solution acts to neutralize acidic materials such as HF or the like as contained in the water within the neutralization tank 61. The neutralized water within the neutralization tank 61 is driven by the pump 36 and then drained out as waste water to the water drain pipe 37. Part of such waste water is sent through the pipe 38 to the spray 63 and then sprayed thereby into the interior of the solid component removing device 54. The remaining waste water is drained out to waste water processing equipment as will be later discussed in the description. As the reaction of Equations (1) and (2) takes place due to the water in the waste water being sprayed from the spray 63 also, it is possible to reduce the use amount of new water to be sprayed from the spray 62. This results in a decrease in amount of the waste water being drained through the water drain pipe 37. The water as sprayed by the sprays 62, 63 absorbs acidic gases that reside within the exhaust

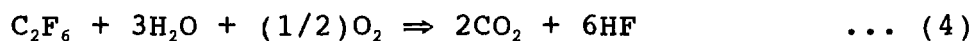
gas to be supplied to inside of the solid component removing device 54 to thereby remove acidic gases away from the exhaust gas.

5       The exhaust gas which is drained out of the solid component removing device 54 is then introduced into the reactor 11 through the pipe 26—practically, to the space 14 of the heating unit 12. Water (reactive water) that is guided by the water supply pipe 35 is added to the exhaust gas within the space 14. In lieu  
10       of this water, water vapor or steam may be added to the exhaust gas. The exhaust gas and the added water within the space 14 are heated up by the heater device 13 so that the water becomes a steam. The exhaust gas as heated up by the heating unit 12 is then supplied  
15       through the duct 15 to the space 19 within the reactor 16. The exhaust gas is further heated up by the heater device 18 within the space 19 up to a temperature which ranges from 650 to 750°C. The heated exhaust gas flows into the inside of the catalyst layer 17. The  
20       catalyst layer 17 is filled with an alumina-based ( $\text{Al}_2\text{O}_3$ ) catalyst—that is, a catalyst which has a composition of 80% of  $\text{Al}_2\text{O}_3$  and 20% of  $\text{NiO}_2$ .  
Practically, such alumina-based catalyst is installed within the reactor 16 while making up an exchangeable  
25       cartridge type structure.  $\text{CF}_4$  that is contained in the

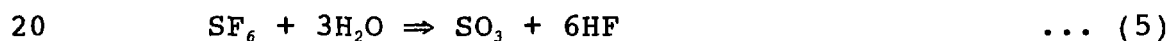
exhaust gas is decomposed into HF and CO<sub>2</sub> while being accelerated in reaction with the reactive water by the chemical reaction of the catalyst in a way as given by Equation (3).



Upon decomposition of 1 mole of CF<sub>4</sub>, 4 mole of hydrofluoric acid (HF) is produced, which is four times greater in mount than the former. Note here that in case the PFC contained in the exhaust gas is C<sub>2</sub>F<sub>6</sub>,  
10 reaction such as defined by Equation (4) occurs causing C<sub>2</sub>F<sub>6</sub> to be decomposed into CO<sub>2</sub> and HF.



Oxygen for use during the reaction of Equation (4) is supplied as air to the interior space 14 via an air  
15 supply pipe (not shown). This air is heated up within the spaces 14, 19 and is then supplied to the catalyst layer 17. Alternatively, in case SF<sub>6</sub> is used as the PFC, reaction defined by Equation (5) takes place causing SF<sub>6</sub> to be decomposed into SO<sub>3</sub> and HF.



Upon decomposition of 1 mole of SF<sub>6</sub>, 1 mole of SO<sub>3</sub> and 6 moles of HF which is six times greater in mount than it are produced.

The water that is guided by the water supply pipe  
25 33 is sprayed by the spray 23 within the acidic gas

removing device 22. This water is collected by the  
acidic gas removing device 22 into the cooler device  
20. The water within the cooler device 20 is driven by  
the pump 29 so that it is drained to the water drain  
5 pipe 30. A portion of this water is supplied by the  
pipe 32 to the spray 21 whereas another portion of it  
is supplied by the pipe 31 to the spray 24; then,  
these are sprayed from respective ones.

The high-temperature exhaust gas which was drained  
10 out of the catalyst layer 17 and which contains  $\text{CO}_2$  and  
HF as decomposed gases is introduced into the cooler  
device 20. This high-temperature exhaust gas is then  
cooled down by the water being continuously sprayed  
from the spray 21 within the cooler device 20 to a  
15 temperature less than or equal to  $100^\circ\text{C}$ . A portion of  
HF as produced by decomposition of  $\text{CF}_4$  is resolved into  
the sprayed water and then removed away. Cooling of  
the exhaust gas may alternatively be carried out by  
bubbling the exhaust gas into water within a water  
20 tank. The temperature-decreased exhaust gas is  
introduced into the acidic gas removing device 22. The  
exhaust gas comes into contact with the water being  
sprayed from the sprays 23, 24 within the acidic gas  
removing device 22. Whereby, the acidic gas (produced  
25 by decomposition of PFC) such as HF contained in the

exhaust gas is solved into such water and thus is removed away from the exhaust gas. In order to enhance the contact efficiency between the exhaust gas and the water while at the same time improving the efficiency of acidic gas removal, plastic-made ラヒシリング is filled within the acidic gas removing device 22. HF is reduced in amount by the acidic gas removing device 22 to fall within a range of from several % to 1 ppm or less. The resultant harmless exhaust gas is then drained away through the driving blower 25 and exhaust duct 28 plus exhaust gas cylinder 52 toward the external environment. In addition, the water that has absorbed acidic gases is drained by the acidic gas removing device 22 into the cooler device 20.

15       The interior of an entire system including the pre-processing tower 10, the reactor 11, the cooler device 20 and acidic gas removing device 22 is retained by the blower 25 at negative pressures to thereby prevent leakage of HF or the like contained in the exhaust gas toward the outside of this system. Additionally the acidic gas removing device 22 is also modifiable to employ the bubbling scheme. Note however that either the spray scheme or the filling tower scheme is superior because of its advantage as to reduced pressure losses and the capability to downsize

the blower for gas exhaust use.

The alkali water solution within the alkali tank 39 is driven by the pump 40 so that it is supplied through a pipe 41 to the interior of the cooler device 20. The alkali solution is used within the cooler device 20 to neutralize specific acidic substances such as HF and the like which are contained in the water drained out of the acidic gas removing device 22 and the water as sprayed from the spray 21, respectively. The neutralized water within the cooler device 20 is driven by the pump 29 and then drained through the water drain pipe 30 to waste-water treatment equipment (not shown). The wastewater treatment equipment is for removal of fluorine (also including fluorine contained as fluorides) as contained in waste water being supplied by the water drain pipes 30, 37 and also for outward delivery of the waste water from which fluorine was removed away.

The illustrative embodiment is such that all of the semiconductor fabrication apparatuses (etchers and chemical vapor deposition (CVD) equipment) which are installed within the clean room and to which PFC gases are supplied are connected via the duct 7 to the PFC decomposition device 9. With such an arrangement, it is possible to permit a single machine of PFC

decomposition device 9 to process the PFC gases  
drained out of all of them in a concentrated way.

Unlike the prior art, this embodiment is free from the  
need to connect a water supply pipe and a water drain  
5 pipe plus electrical wiring leads to a respective one  
of the plurality of PFC decomposition devices which  
are installed within the clean room and may be  
arranged so that such water supply and drain pipes and  
electrical wiring leads are connected to the single  
10 machine of PFC decomposition device 9. This in turn  
makes it possible to shorten a time taken to install  
the water supply/drain pipes and electrical wiring  
leads while at the same time reducing difficulties in  
installation works thereof.

15 In this embodiment the PFC decomposition device 9  
is installed outside of the clean room 2. Due to this,  
in case a clean room is newly installed, the  
embodiment avoids a need to provide in the clean room  
2 an extra installation space for the PFC  
20 decomposition device 9 and the water supply/drain  
pipes to be connected thereto, thereby enabling  
achievement of likewise size reduction or "downsizing"  
of the clean room 2. Another advantage lies in an  
ability to reduce the capacity of cleaning equipment  
25 for removal of residual contaminants or micro-dusts

within the clean room 2 and that of air-conditioning/adjustment equipment which is operatively associated with the clean room 2. A further advantage lies in an ability to make easier both downsizing of  
5 the clean room 2 and layout alteration of semiconductor fabrication apparatuses. This can be said because the PFC decomposition device 9 and any required water supply/drain pipes connected thereto are not disposed within the clean room 2.

10 In cases where a PFC decomposition device is newly installed for processing of PFC gases as drained out of a plurality of etchers installed within the currently established clean room, installing the PFC decomposition device 9 outside of the clean room 2 in  
15 the way of this embodiment makes it easier to move the semiconductor fabrication apparatuses such as the etchers and replace such semiconductor fabrication apparatuses in accordance with a change of products to be manufactured. To be brief, this embodiment is  
20 capable of achieving a flexibility-increased semiconductor factory through alteration and recombination of flexible production lines. It is also possible to noticeably shorten or eliminate a time taken to move the semiconductor fabrication  
25 apparatuses. In addition, it is possible for this

embodiment to introduce the PFC decomposition device 9 by merely installing the duct 7 within the clean room 2, without requiring movement of such semiconductor fabrication apparatuses. For this reason, upon  
5 introduction of the PFC decomposition device 9, it becomes possible to shorten a halt/shut-down time period of the semiconductor fabrication apparatus otherwise occurring due to the semiconductor production lines within such clean room 2.

10 This embodiment is such that the reactor 11 is subdivided into the heating unit 12 and the reaction unit 16 each having its own heater device, with the heating unit 12 and the reaction unit 16 installed on the indoor floor of a little house. This arrangement  
15 for division of the reactor 11 into two parts of the heating unit 12 and reaction unit 16 is employed because in view of the concentrated processing of PFC gases as drained out of all the semiconductor fabrication apparatuses which are installed within the  
20 clean room 2 and to which PFC gases are supplied, the total height of reactor 11 (i.e. the height of heating unit 12 and that of reaction unit 16) becomes extremely significant to an extent that which makes it difficult to transport them by land vehicles.

25 This embodiment merely requires connection between

the gas exhaust portion of an etcher to be additionally provided and the duct 7; thus, it is possible to readily perform additional installation of any extra etcher within the clean room 2. A PFC gas to  
5 be drained out of the added etcher may be processed by the PFC decomposition device 9 which is installed outside of the clean room 2. Note here that the embodiment is arranged to remove any acidic gas (or carbon monoxide) as drained out of an etcher by the  
10 acid gas removing device 4 (or carbon monoxide removal device 6) that is installed at a location adjacent to the outlet or "exit" port of the etcher; thus, it is possible to preclude damages of working environment within the clean room 2 even where the duct 7 is  
15 damaged within the clean room 2. Additionally, improving the reliability of the duct 7 enables installation of harmful gas processing equipment for treatment of these harmful gases (carbon monoxide, chlorine and others) at a location outside of the  
20 clean room 2 and also in the upstream of the PFC decomposition device 9 to thereby achieve concentrated processing of these harmful gases.

In this embodiment, acidic substances such as HF and the like which are separated from exhaust gases  
25 and resolved in water is neutralized by supplying

alkali solution to the neutralization tank 11 and the cooler device 20; thus, respective neutralization-processed waste water as drained out of the neutralization tank 11 and cooler device 20 improve in  
5 absorption ability (solubility) of acidic gases such as HF and the like as contained in the exhaust gases. Part of the waste water may be reused as the water to be sprayed from the corresponding sprays 63 and 24 to thereby make it possible to enhance the efficiency of  
10 removal of acidic gases contained in the exhaust gases.

In cases where the PFC decomposition device 9 which performs concentrated processing of PFC gases as drained out of all the etchers within the clean room 2 interrupts its PFC gas treatment operation due to  
15 malfunction or the like, semiconductor fabrication processes within such clean room 2 are all halted. In this embodiment, in emergency events in which the PFC decomposition device 9 stops, let the three-way valve 8 rotate to thereby provide connection between the  
20 duct 7 on the upstream side of the three-way valve 8 and the pipe 60. The exhaust gas which was drained out of each etcher is driven by the blower 50 to be temporarily introduced into the acidic gas removing device 47 through the pipe 60 and gas collection duct  
25 49, rather than to the PFC decomposition device 9.

Acidic gases that reside in such exhaust gas will be removed by the acidic gas removing device 47.

Generally the gas processing capacity of the acidic gas removing device 47 is about ten to fifty times

5 greater than the capacity of exhaust gas being supplied by the duct 7 to the PFC decomposition device 9. Due to this, it is possible for the acidic gas removing device 47 to remove the acidic gases residing in the exhaust gas being supplied to the PFC

10 decomposition device 9. The resulting exhaust gas from which the acidic gases are removed is drained out of the exhaust gas cylinder 52 to external environment.

During introduction of such exhaust gas via the pipe 60 to the acidic gas removing device 47, the required  
15 operation check and repair of the PFC decomposition device 9 which is malfunctioning are carried out.

After completion of repairing tasks, rotate the three-way valve 8 to supply the exhaust gas to the PFC decomposition device 9. In this way, this embodiment  
20 is capable of supplying the exhaust gas via the pipe 60 to the acidic gas removing device 47 in emergency events such as malfunction or the like of the PFC decomposition device 9 whereby it becomes possible to perform operation check and repair works without  
25 requiring interruption of the semiconductor

fabrication processes within the clean room 2. As a  
time period required for operation check and repair of  
the PFC decomposition device 9 is about one to two  
days, the amount of a PFC gas which is released to  
5 external environment without being decomposed stays at  
an extremely small rate with respect to the PFC gas  
amount to be yearly processed by the PFC decomposition  
device 9 in this embodiment.

This embodiment is also capable of using the PFC  
10 decomposition device 9 to process a PFC gas which is  
drained out of the CVD apparatus as installed in the  
clean room 2.

In case a machine room for installation of air  
purification apparatus for purifying indoor air of the  
15 clean room 2 and air-conditioning equipment of clean  
room 2 is provided inside of the machine-room  
semiconductor fabrication factory 1 or alternatively  
within a building associated with the semiconductor  
fabrication factory, the PFC decomposition device 9  
20 may be installed within such machine room. The PFC  
decomposition device 9 in which the reactor 11 is  
divided into the heating unit 12 and reaction unit 16  
does not require any reconstruction for making the  
ceiling of such machine room higher and thus is  
25 readily installable in the machine room.

It is also permissible to avoid installation of the three-way valve 8 and pipe 60 and instead install PFC decomposition devices 9 in parallel to the duct 7 while causing these PFC decomposition devices 9 to offer switchable operability. With such an arrangement, even if one PFC decomposition device 9 malfunctions then the other PFC decomposition device 9 is employable to perform exhaust gas processing (removal of residual acidic gases and PFC decomposition treatment). Additionally, the operation check and repair of a malfunctioning PFC decomposition device 9 may be done while continuously performing semiconductor fabrication processes.

An explanation will be given of another embodiment of the PFC decomposition device with reference to Fig. 3 below. A PFC decomposition device 9A of this embodiment is arranged so that a water vaporizer 55 is installed at the pipe 27 of the PFC decomposition device 9, with the water supply pipe 35 being connected to the water vaporizer 55 and with a steam supply pipe 56 provided to couple together the water vaporizer 55 and the space 14 of the heating unit 12. The remaining arrangement of the PFC decomposition device 9A is the same as that of the PFC decomposition device 9 stated supra. Within the water vaporizer 55,

a high-temperature exhaust gas to be supplied by the pipe 27 flows in a heat transfer pipe (not shown) whereas water (reactive water) being supplied by the water supply pipe 35 flows on the shell side. Water is  
5 heated up by the exhaust gas within the water vaporizer 55 to thereby become a steam. The steam thus generated is supplied through the steam supply pipe 56 to the space 14 and is then added to the exhaust gas.

The PFC decomposition device 9A offers the same  
10 function as the PFC decomposition device 9 and can obtain the same effects and advantages as the latter. Since the PFC decomposition device 9A is designed to use the heat of an exhaust gas drained out of the reaction unit 16 to change the reactive water into a  
15 steam, it is possible to reduce the thermal energy being applied for heat-up of the exhaust gas at the heating unit 12 of the PFC decomposition device 9A. This is because no energies are required to change the reactive water into a steam in the PFC decomposition  
20 device 9.

Even where the PFC decomposition device 9A is used in place of the PFC decomposition device 9 in the PFC processing apparatus 44 shown in Fig. 1, it is possible to obtain similar effects occurring in the  
25 PFC processing apparatus 44 of Embodiment 1.

An explanation will be given of another embodiment of the PFC decomposition device with reference to Fig. 4 below. A PFC decomposition device 9B of this embodiment is arranged so that a gas pre-heater 57 is  
5 installed at the pipe 26 of the PFC decomposition device 9 with the pipe 26 connected via this gas preheater 57 to the space of the heating unit 12. The other arrangement of the PFC decomposition device 9B is the same as that of the PFC decomposition device 9.  
10 A high-temperature gas which is drained out of the catalyst layer 17 and supplied by the pipe 27 flows in a heat-transfer pipe (not shown) as provided within the gas preheater 57 whereas an exhaust or waste gas being supplied via the pipe 26 flows on the shell side  
15 within the gas preheater 57. The exhaust gas being supplied by the pipe 26 is heated up by the high-temperature exhaust gas as supplied by the pipe 27 and then introduced into the space 14 in the state that its temperature rose up. The high-temperature exhaust  
20 gas flowing in the heat transfer pipe that is provided within the gas preheater 57 is introduced into the cooler device 20 and then cooled down in the way stated previously.

The PFC decomposition device 9B offers the same  
25 function as the PFC decomposition device 9 and can

obtain the same effects and advantages as the latter. Since the PFC decomposition device 9B is arranged to use the heat of an exhaust gas as drained out of the reaction unit 16 to heat up the exhaust gas being  
5 supplied to the heating unit 12, it is possible to reduce the thermal energy being applied for heat-up of the waste gas at the heating unit 12 of the PFC decomposition device 9B.

Even where the PFC decomposition device 9B is used  
10 in lieu of the PFC decomposition device 9 in the PFC processing apparatus 44 shown in Fig. 1, similar effects occurring in the PFC processing apparatus 44 of Embodiment 1 are obtainable.

## 15        Embodiment 2

A PFC processing apparatus in accordance with another embodiment of the present invention will be explained with reference to Fig. 5. The PFC processing apparatus 44A of this embodiment is arranged so that  
20 the exhaust duct 28 is connected to the acidic gas removing device 47 in the PFC processing apparatus 44 shown in Fig. 1. An arrangement of the other part of PFC processing apparatus 44A is the same as that of the PFC processing apparatus 44. In this embodiment,  
25 an exhaust gas which was drained out of the acidic gas

removing device 22 of the PFC decomposition device 9  
is supplied through the exhaust gas duct 28 to the  
acidic gas removing device 47. Due to this, in case  
the acidic gas removing device 22 decreases in acidic  
5 gas removal functionality, any acidic gas to be  
produced by PFC decomposition within the reaction unit  
16 can be removed by the acidic gas removing device 47.  
In this way, it is possible to use the acidic gas  
removing device 47 as a backup of the acidic gas  
10 removing device 22. The PFC processing apparatus 44A  
of this embodiment can also obtain the effects  
occurring at the above-stated PFC processing apparatus  
44.

In the PFC processing apparatus 44A of this  
15 embodiment, the acidic gas removing device 22 of the  
PFC decomposition device 9 may be deleted to remove  
the acidic gas as produced by PFC decomposition within  
the reaction unit 16 not by the acidic gas removing  
device 22 but by the acidic gas removing device 47. In  
20 this case the acidic gas removing device 47 is  
designed to operate continuously during semiconductor  
manufacturing. In the PFC processing apparatus 44A, it  
is also possible to replace the PFC decomposition  
device 9 with either one of the PFC decomposition  
25 device 9A and the PFC decomposition device 9B.

Embodiment 3

A PFC processing apparatus in accordance with still another embodiment of the present invention will be explained below. The PFC processing apparatus 44B of this embodiment is arranged so that the PFC decomposition device 9 in the PFC processing apparatus 44 shown in Fig. 1 is replaced by a PFC decomposition device 9C shown in Fig. 6. The other arrangement of the PFC processing apparatus 44B is the same as that of the PFC processing apparatus 44. An arrangement of the PFC decomposition device 9C that is used in the PFC processing apparatus 44B will be explained. Whereas the PFC decomposition device 9 is a wet-type PFC decomposition device in which waste water generates the PFC decomposition device 9C used in this embodiment is a dry-type PFC decomposition device in which no waste water generates.

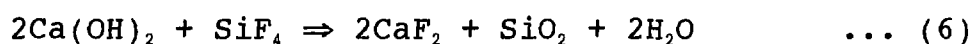
The PFC decomposition device 9C is equipped with a reaction unit 11, filter devices 65, 66 and fine-particle/powder silo 81. The duct 7 is coupled to a lower-part space 68 of the filter device 65. The pipe 26 which is coupled to the heating unit 12 is coupled to an upper-part space of the filter device 65. The pipe 27 is coupled to a lower space 68 of the filter device 66. The exhaust gas duct 28 is coupled to an

upper space 69 of the filter device 66. The powder silo 81 is connected by a pipe 82 to the duct 7 at a location in the downstream of the three-way valve 8 and also connected by a pipe 83 to the pipe 27,  
5 respectively.

An arrangement of the filter device 65, 66 will be explained with reference to Fig. 7. The filter device 65, 66 includes a plurality of tubular filter elements 67A, 67B, 67C or the like which are installed within a  
10 vessel-like housing 80. Each filter element has a filter fabric or cloth (not shown) which is wound around an outer surface. An inside space of the vessel 80 is subdivided by each filter element into the lower space 68 and upper space 69. An air supply pipe 70A  
15 with a valve 71A provided therein is inserted from the upper part into the inside of filter element 67A. Similarly, an air supply pipe 70B with a valve 71B provided therein is inserted from the upper part into the inside of filter element 67B; an air supply pipe  
20 70C with a valve 71C provided therein is inserted from the upper part into the inside of filter element 67C. A solid component reservoir tank 72 is connected through the valve 77A to a bottom portion of the vessel 80 of the filter device 65. A screw conveyer 74  
25 is disposed beneath the solid component reservoir tank

72. A solid component reservoir tank 73 is connected via the valve 77B to the bottom of the vessel 80 of the filter device 66. A screw conveyer 75 is laid out below the solid component reservoir tank 73.

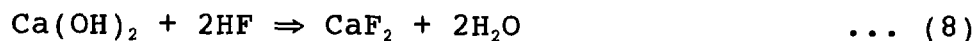
5           As has been described in Embodiment 1, the exhaust gas being guided by the duct 7 contains several impurities along with PFC ( $\text{CF}_4$ ), examples of which are an impurity that produces solid components by reaction with water such as  $\text{SiF}_4$  and  $\text{WF}_6$  as produced during  
10 etching processes and an impurity that is a solid component such as  $\text{SiO}_2$  and  $\text{WO}_3$  or else. This exhaust gas is supplied into the lower space 68 of the filter device 65. Power particles of Ca salts as filled within the powder silo 81—typically, powder of  
15 calcium hydroxide [ $\text{Ca}(\text{OH})_2$ ]—is supplied through the pipe 82 to the duct 7 when a valve (not shown) opens. The powder  $\text{Ca}(\text{OH})_2$  is mixed into the exhaust gas and then flows into the lower space 68 of the filter device 65.  $\text{SiF}_4$  and  $\text{WF}_6$  contained in the exhaust gas  
20 experience neutralization reaction with  $\text{Ca}(\text{OH})_2$  as indicated in Equations (6) and (7) to thereby produce  $\text{CaF}_2$ ,  $\text{SiO}_2$  and  $\text{WO}_3$ .



25           Further, HF contained in such exhaust gas

experiences chemical reaction with  $\text{Ca(OH)}_2$  indicated by Equation (8) below to thereby produce calcium fluoride ( $\text{CaF}_2$ ). Solid components such as  $\text{SiO}_2$  and  $\text{WO}_3$  contained in the exhaust gas and unreacted  $\text{Ca(OH)}_2$  along with  
5  $\text{CaF}_2$ ,  $\text{SiO}_2$  and  $\text{WO}_3$  as produced by the reaction of Equations (6), (7) and (8) are trapped by the filter cloth installed in each filter element 67 of the filter device 65 and are then removed away from the exhaust gas. The exhaust gas which has passed through  
10 the filter element 67 and contains  $\text{CF}_4$  flows into the spaces 14, 19 within the reactor 11 through the upper space 69 and pipe 26.  $\text{CF}_4$  is decomposed by the catalyst layer 17 in the way stated previously in Embodiment 1. The exhaust gas being supplied to the  
15 reactor 11 contains none of  $\text{HF}$ ,  $\text{SiF}_4$ ,  $\text{WF}_6$ ,  $\text{SiO}_2$  and  $\text{WO}_3$ .

The acidic gas ( $\text{HF}$ ) that was produced by decomposition of  $\text{CF}_4$  at the catalyst layer 17 is introduced into the space 68 of the filter device 66. Opening a valve (not shown) permits  $\text{Ca(OH)}_2$  powder  
20 within the powder silo 81 to be supplied by the pipe 83 to the pipe 27 and then mixed into the exhaust gas.  $\text{Ca(OH)}_2$  also is introduced into the space 68.  $\text{HF}$  experiences occurrence of neutralizing reaction with  $\text{Ca(OH)}_2$  as given by Equation (8) to thereby produce  
25  $\text{CaF}_2$ .



This  $\text{CaF}_2$  and unreacted  $\text{Ca(OH)}_2$  are captured by the filter cloth within the filter device 66. During penetration of a layer of  $\text{CaF}_2$  and unreacted  $\text{Ca(OH)}_2$  and  $\text{CaF}_2$  which was formed as a result of capture at surfaces of the filter cloth, unreacted HF reacts with such  $\text{Ca(OH)}_2$  and is then fixed. Chemical reaction between HF and  $\text{Ca(OH)}_2$  is accelerated at higher temperatures. As the exhaust gas drained out of the catalyst layer 17 is high in temperature, its chemical reaction is accelerated. Coolant air is supplied by a pipe 76 to the upstream side of the filter element 67 of the filter device 66, that is, into the lower space 68. This coolant air is used to cool the exhaust gas within the lower space 68 whereby the temperature of such exhaust gas is adjusted so that it is greater than or equal to about  $200^\circ\text{C}$  and yet below  $300^\circ\text{C}$ . This is because the heat-resistance temperature of filter cloth is  $300^\circ\text{C}$ . Preferably the supply position of coolant air is in the downstream of a junction point of the pipe 27 and pipe 83. This is required because HF and  $\text{Ca(OH)}_2$  powder are mixed and contacted together at higher temperatures to thereby efficiently execute the neutralization reaction. Under the high temperature condition,  $\text{Ca(OH)}_2$  becomes CaO and then the

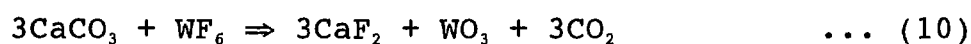
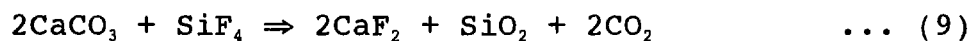
activity as the alkali lowers. In this embodiment, in the upstream side since the reaction water is added to use the perfluoride decomposing reaction, many water components is existed, even under the high temperature condition,  $\text{Ca}(\text{OH})_2$  exists. For this reason, since the reaction shown in the formula (8) is the high temperature condition, the reaction speed is accelerated, and then HF is removed effectively. As the blower 25 is driving, the exhaust gas is drained from the filter device 66 to the exhaust duct 28. The exhaust gas being drained to the exhaust duct 28 contains no acidic gases. The exhaust gas within the exhaust duct 28 is cooled by the coolant air which is supplied from the pipe 84 into the exhaust duct 28 and thus drops down at  $50^\circ\text{C}$ . Due to supplement of the air which decreases to  $50^\circ\text{C}$ , it will no longer happen that  $\text{H}_2\text{O}$  generated by the reaction of Equation (8) is condensed to change into a liquid.

At the filter devices 65, 66, a difference in pressure between the upper space 69 and lower space 68 is detected by a differential pressure meter or gauge (not shown). At a filter device in which such pressure difference reaches a preset value, e.g. filter device 66, its filter elements are subjected to back washing. More specifically, the first step is to open the valve

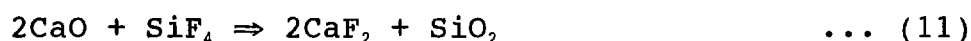
71A. Backwash-use water which is supplied from the air supply pipe 70A is drained to the inside of filter element 67A and then passes through the filter cloth and thereafter is drained to the lower space 68. Due to the flow of this backwash-use water, solid components (such as calcium fluoride, unreacted  $\text{Ca(OH)}_2$ , and the like) which are attached to outer surfaces of the filter cloth drop down as a balk onto the bottom of the vessel 80. After having completed the back washing of the filter element 67A, the valve 70C is driven to open so that air is supplied from the air supply pipe 70B to the filter element 67B to thereby perform back washing of the filter element 67B. Next, the air being supplied from the air supply pipe 70B is used to perform back washing of the filter element 67C. By opening the valve 77B, solid components 79 that are accumulated at the bottom of the vessel 80 are drained to the interior of solid component reservoir tank 73. Further, the solid components 79 which have dropped down through the opened valve 78B are transferred by the screw conveyer 75 toward a solid matter collection silo (not shown) and then stored therein. Each filter element of the filter device 65 is subject to back washing in a similar way, causing the solid components 79 within the vessel 80 to be drained into the solid

component reservoir tank 72 when letting the valve 77A open. Such solid components also drop down through the valve 78A and are then sent by the screw conveyer 74 to the above-noted solid matter reservoir tank. The  
5 solid components 79 within the solid matter reservoir tank are for later reuse as the raw material of cement.

Another example of the Ca salt useable in place of  $\text{Ca}(\text{OH})_2$  is powder of calcium carbonate ( $\text{CaCO}_3$ ) or calcium oxide ( $\text{CaO}$ ). Regarding reactivity with acidic  
10 gases or the like,  $\text{Ca}(\text{OH})_2$  is higher than  $\text{CaCO}_3$  and  $\text{CaO}$ ; thus, it is preferable to use  $\text{Ca}(\text{OH})_2$ . Reaction with acidic gases or else takes place on surfaces; thus, in order to increase the surface area, it is preferable that Ca salt is in the form of powder. In  
15 case  $\text{CaCO}_3$  is added to the exhaust gas within the duct 7, neutralization reaction with  $\text{SiF}_4$  and  $\text{WF}_6$  as defined by Equations (9) and (10) takes place.



20 In case  $\text{CaO}$  is added to the exhaust gas within the duct 7, neutralization reaction with  $\text{SiF}_4$  and  $\text{WF}_6$  as given by Equations (11) and (12) occurs.



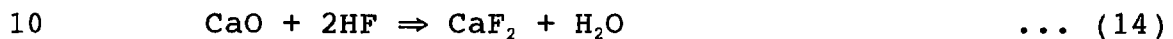
25  $\text{CaF}_2$ ,  $\text{SiO}_2$  and  $\text{WO}_3$  or else as produced through each

reaction of them are removed away by the filter cloth of the filter device 65.

In case  $\text{CaCO}_3$  is added to the exhaust gas within the pipe 27, neutralization reaction with HF as  
5 represented by Equation (13) occurs.



In case  $\text{CaO}$  is added to the waste gas within the pipe 27, neutralization reaction with HF as given by Equation (14) occurs.



$\text{CaF}_2$  or else which was produced by each reaction of them is removed by the filter cloth of filter device 66.

In Embodiments 1 and 2 using the wet-type PFC  
15 decomposition devices, it is required to remove fluorides that are contained in the waste water as guided by the water drain pipes 30, 37 in waste-water processing equipment. Due to this, in the wastewater processing equipment, the following processing is done.  
20 More specifically, add Ca salt ( $\text{CaCO}_3$  or  $\text{Ca}(\text{OH})_2$ ) into waste water; then, stir it. Solid components such as calcium fluoride produced by reaction between Ca salts and HF being contained in the waste water and unreacted Ca salts and others precipitate for  
25 separation. Further, add a flocculant to the waste

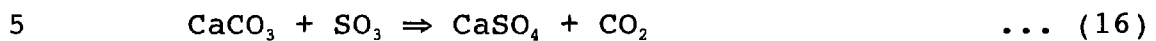
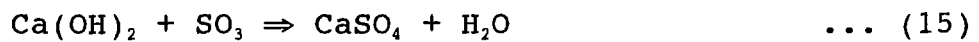
water, causing such solid components with micro-particle diameters to aggregate or flocculate for separation. The resultant solid components thus separated such as calcium fluorides are subject to  
5 dehydration and drying processes for later reuse as the raw material of cement. Embodiments 1 and 2 which use water to remove solid components and acidic gases in the exhaust gas should require execution of the above-stated complicated processing for removal of  
10 fluorides as contained in the waste water, resulting in production of a great amount of water. The waste water from the wastewater processing equipment contains therein an increased amount of calcium ions and is drained externally as industrial waste water.  
15 Although Embodiments 1 and 2 are capable of obtaining various effects stated above, these require wastewater processing facilities which perform complicated processing for fluoride removal.

In contrast, this embodiment is arranged to add Ca  
20 salt to the exhaust gas whereby it is possible to salvage fluorides in the exhaust gas as a reusable solid content without producing any waste water. Obviously, this embodiment requires no wastewater processing facilities. Installing the PFC processing  
25 apparatus of this embodiment which is extremely less

in water use amount makes it possible to install a semiconductor fabrication factory in land areas with poor water resources. In addition, even if the environmental emission standards become stricter in near future, the embodiment may readily cope with such strictness. As the embodiment is free from a risk of waste water production, any water drain pipes are no longer required; thus, it is possible to simplify the facilities when compared to Embodiments 1 and 2 stated supra. Generally, chemical reaction in the dry state is slower in reaction rate and less in efficiency than chemical reaction in an ionized state in wet-type ones. However, wet-type PFC decomposition devices inherently require addition of an access amount of calcium salt ( $\text{Ca}(\text{OH})_2$ ,  $\text{CaCO}_3$ ,  $\text{CaO}$  or else) which is several times greater than a theoretically determined value in order to remove a low concentration of F ions in waste water so that the requisite amount of Ca salt is nearly equal to that of the wet-type PFC decomposition devices.

In case  $\text{SF}_6$  is used as the PFC gas in an etcher(s),  $\text{SO}_3$  is produced by reaction of Equation (5) at the catalyst layer 17. This  $\text{SO}_3$  reacts with the Ca salt added to the interior of pipe 27, resulting in production of calcium sulfate ( $\text{CaSO}_4$ ). Practically

explaining, in case any one of  $\text{Ca(OH)}_2$ ,  $\text{CaCO}_3$  and  $\text{CaO}$  is added, reaction represented by any one of Equations (15) to (17) occurs.



This calcium sulfate is later reusable as the raw material of cement.

This embodiment can obtain the effects and  
10 advantages occurring in Embodiment 1, including (1) the ability to downsize the clean room 2 and to readily perform layout changes of the semiconductor fabrication apparatuses, (2) easing transfer of semiconductor fabrication apparatuses such as etchers  
15 or the like within the currently established clean room and replacement of any semiconductor fabrication apparatus, (3) capability to shorten the interruption time period of semiconductor manufacture using semiconductor fabrication lines within the clean room  
20 2 upon introduction of the PFC decomposition device 9, (4) achieving enhanced transportability by land vehicles because of subdivision of the heating unit 12 and reaction unit 16, (5) ability to readily perform additional installation of etchers within the clean  
25 room 2 because what is required is to merely connect

together the gas exhaust part of an etcher to be additionally provided and the duct 7, and (6) improvement in catalyst-based PFC decomposition efficiency due to the fact that no solid components  
5 are produced through reaction with reactive water.

In the PFC decomposition device 9C of Fig. 6, slurry of Ca salt ( $\text{CaCO}_3$  or  $\text{Ca(OH)}_2$ ) may be supplied to the pipe 27 in lieu of supplement of Ca salt powder. The Ca salt is such that slurry is more readily  
10 transportable than powder, thereby facilitating supplement to the pipe 27. Water component of the Ca salt slurry is vaporized into a steam when coming into contact with a high-temperature exhaust gas being drained out of the reaction unit 16. An acidic gas  
15 ( $\text{HF}$ ) in the exhaust gas reacts with Ca salt to produce calcium fluorides. The steam is guided to pass through the filter cloth and then release toward external environment through the exhaust duct 28 and exhaust cylinder 52. This embodiment is arranged to supply  
20 coolant water from the pipe 84 to thereby ensure that an exhaust gas temperature within the exhaust duct 28 stays at  $100^\circ\text{C}$ . Thus it is possible to avoid unwanted flocculation of the steam within the exhaust duct 28.

The PFC decomposition device 9C of this embodiment  
25 is also applicable to PFC processing apparatus with

its associated PFC decomposition device installed within the clean room 2.

Other embodiments of the dry-type PFC decomposition device will be explained. A PFC decomposition device 9D (see Fig. 8) is arranged so that a water vaporizer 55 is installed at the pipe 27 in a similar way to that of the PFC decomposition device 9A while heating up the reactive water to be supplied by a water supply pipe 35. A PFC decomposition device 9E shown in Fig. 9 is designed so that a gas preheater 57 is installed at the pipe 27 for heating an exhaust gas being guided by a pipe 26. A respective one of the PFC decomposition devices 9D and 9E may be installed in the PFC processing apparatus 44B in place of the PFC decomposition device 9C of Embodiment 3. Further in the PFC processing apparatus 44A also, each of the PFC decomposition devices 9D and 9E is installable in lieu of the PFC decomposition device 9.

In a liquid crystal manufacturing system including a liquid crystal manufacturing factory also, more than one etcher (or CVD apparatus) using PFC gases is installed within a clean room as liquid crystal manufacturing equipment. Due to this, applying any one of the above-stated PFC decomposition devices 44, 44A

and 44B to the liquid crystal manufacturing system makes it possible to concentratedly process PFC gases as drained out of all the etchers within the clean room. The PFC decomposition device (any one of the PFC decomposition devices 9, 9A, 9B, 9C, 9D and 9E) of such PFC processing apparatus is installed outside of the clean room in a similar way to Embodiments 1 and 2.

Although the PFC processing apparatus of each of the embodiments stated supra employs the catalyst-use PFC decomposition device as its PFC decomposition device, this PFC decomposition device is replaceable by a combustion-scheme PFC decomposition device for performing decomposition through combustion or alternatively a plasma-scheme PFC decomposition device for decomposition by changing PFC into a plasma. Additionally the blower 25 is replaceable with an ejector(s). Each of the above-stated embodiments is capable of decomposing PFCs including but not limited to  $\text{CF}_4$ ,  $\text{CHF}_3$ ,  $\text{C}_2\text{F}_6$ ,  $\text{C}_3\text{F}_8$ ,  $\text{C}_4\text{F}_6$ ,  $\text{C}_5\text{F}_8$ ,  $\text{NF}_3$ , and  $\text{SF}_6$ .

According to the present invention, it is possible to downsize a clean room with either semiconductor fabrication apparatus or liquid crystal manufacturing apparatus installed therein. In case the invention is applied to the currently established clean room, it is no longer required to move the semiconductor

fabrication apparatus or liquid crystal manufacturing apparatus within the clean room in order to install more than one perfluoride decomposition device.

What is claimed is:

[Claim 1]

A perfluoride processing apparatus characterized  
5 by comprising an exhaust gas pipe connected to a  
plurality of semiconductor fabrication apparatuses  
installed within a clean room with perfluoride  
supplied thereto for permitting flow of an exhaust gas  
containing therein said perfluoride as drained out of  
10 the semiconductor fabrication apparatuses, and a  
perfluoride decomposition device connected to said  
exhaust gas pipe and installed outside of said clean  
room for decomposing said perfluoride as contained in  
said exhaust gas to be guided by said exhaust gas pipe.

15

[Claim 2]

The perfluoride processing apparatus as recited in  
claim 1, wherein said exhaust gas pipe is connected to  
all of said semiconductor fabrication apparatuses as  
20 installed in said clean room with said perfluoride  
supplied thereto.

[Claim 3]

The perfluoride processing apparatus as recited in  
25 claim 1, wherein said apparatus further comprises an

exhaust gas flow path changing device provided at said  
exhaust gas pipe on the upstream side of said  
perfluoride decomposition device, and a bypass pipe  
connected to said exhaust gas flow path changing  
5 device for bypassing said perfluoride decomposition  
device to be coupled to an acidic gas removing device  
of factory acidic gas processing equipment.

[Claim 4]

10 The perfluoride processing apparatus as recited in  
claim 1, wherein an exhaust pipe is provided for  
introducing an exhaust gas as drained out of said  
perfluoride decomposition device to said acidic gas  
removing device.

15

[Claim 5]

The perfluoride processing apparatus as recited in  
any one of the preceding claims 1 to 4, wherein said  
perfluoride decomposition device includes a heating  
unit having a first heater device with said exhaust  
20 gas supplied to said heating unit and a reaction unit  
having a second heating device and a catalytic layer  
with said exhaust gas as heated up by said heating  
unit being supplied thereto.

25

[Claim 6]

The perfluoride processing apparatus as recited in any one of the preceding claims 1 to 4, wherein said perfluoride decomposition device comprises a solid  
5 component removing device with said exhaust gas supplied thereto, a reaction unit for decomposing perfluoride to which said exhaust gas drained out of said solid component removing device is supplied and in which a catalytic layer is provided, and an acidic  
10 substance removing device for removal of any acidic substance being contained in said exhaust gas as drained out of said reaction unit.

[Claim 7]

15 The perfluoride processing apparatus as recited in claim 6, wherein the apparatus comprises a water supply device for supplying at least water in contact with said exhaust gas to said solid component removing device and said acidic substance removing device  
20 respectively.

[Claim 8]

The perfluoride processing apparatus as recited in any one of the preceding claims 1 to 4, wherein said  
25 perfluoride decomposition device comprises a reaction

unit for decomposing said perfluoride, in which unit a catalytic layer provided and to which said exhaust gas is supplied, and an acidic substance removing device for removing reaction products as produced by reaction  
5 of acidic material contained in said exhaust gas drained out of said reaction unit with Ca salts.

[Claim 9]

A perfluoride processing apparatus characterized  
10 by comprising an exhaust gas pipe connected to a plurality of liquid crystal manufacturing apparatuses installed within a clean room with perfluoride supplied thereto for permitting flow of an exhaust gas containing therein said perfluoride as drained out of  
15 the liquid crystal manufacturing apparatuses, and a perfluoride decomposition device connected to said exhaust gas pipe and installed outside of said clean room for decomposing said perfluoride as contained in said exhaust gas to be guided by said exhaust gas pipe.

20

[Claim 10]

The perfluoride processing apparatus as recited in claim 9, wherein said exhaust gas pipe is connected to all of said liquid crystal manufacturing apparatuses  
25 as installed in said clean room with said perfluoride

supplied thereto.

[Claim 11]

5       The perfluoride processing apparatus as recited in  
claim 9, wherein said apparatus further comprises an  
exhaust gas flow path changing device provided at said  
exhaust gas pipe on the upstream side of said  
perfluoride decomposition device, and a bypass pipe  
connected to said exhaust gas flow path changing  
10   device for bypassing said perfluoride decomposition  
device to be coupled to an acidic gas removing device  
of factory acidic gas processing equipment.

[Claim 12]

15       The perfluoride processing apparatus as recited in  
claim 9, wherein an exhaust pipe is provided for  
introducing an exhaust gas as drained out of said  
perfluoride decomposition device to said acidic gas  
removing device.

20

[Claim 13]

      The perfluoride processing apparatus as recited in  
any one of the preceding claims 9 to 12, wherein said  
perfluoride decomposition device includes a heating  
25   unit having a first heater device with said exhaust

gas supplied to said heating unit and a reaction unit having a second heating device and a catalytic layer with said exhaust gas as heated up by said heating unit being supplied thereto.

5

[Claim 14]

The perfluoride processing apparatus as recited in any one of the preceding claims 9 to 12, wherein said perfluoride decomposition device comprises a solid  
10 component removing device with said exhaust gas supplied thereto, a reaction unit for decomposing perfluoride to which said exhaust gas drained out of said solid component removing device is supplied and in which a catalytic layer is provided, and an acidic  
15 substance removing device for removal of any acidic substance being contained in said exhaust gas as drained out of said reaction unit.

[Claim 15]

20 The perfluoride processing apparatus as recited in claim 14, wherein the apparatus comprises a water supply device for supplying at least water in contact with said exhaust gas to said solid component removing device and said acidic substance removing device  
25 respectively.

[Claim 16]

The perfluoride processing apparatus as recited in any one of the preceding claims 9 to 12, wherein said perfluoride decomposition device comprises a reaction  
5 unit for decomposing said perfluoride, in which unit a catalytic layer provided and to which said exhaust gas is supplied, and an acidic substance removing device for removing reaction products as produced by reaction of acidic material contained in said exhaust gas  
10 drained out of said reaction unit with Ca salts.

[Claim 17]

A perfluoride decomposition device characterized by comprising a reaction unit in which a catalytic  
15 layer is provided and to which an exhaust gas containing therein a perfluoride is supplied, said reaction unit decomposing said perfluoride, and an acidic substance removing device for removal of a secondary reactive product as produced by reaction  
20 with Ca salts of an acidic substance being contained in said exhaust gas as drained out of said reaction unit.

[Claim 18]

25 The perfluoride decomposition device as recited in

claim 17, wherein said device has a reactive product removing device for removing a secondary reactive product to be produced by reaction with Ca salts of the substance contained in said exhaust gas to  
5 generate solid matter due to reaction with water and wherein said exhaust gas drained out of said reactive product removing device is supplied to said reaction unit.

10 [Claim 19]

A perfluoride processing method for use with a plurality of semiconductor fabrication apparatuses installed within a clean room for receiving perfluoride as supplied thereto, characterized by  
15 comprising the steps of supplying exhaust gases containing said perfluoride as drained out of the semiconductor fabrication apparatuses to a perfluoride decomposition device installed outside of said clean room and then decomposing said perfluoride by said  
20 perfluoride decomposition device.

[Claim 20]

A perfluoride processing method according to claim 19, wherein a decomposing method of a perfluoride  
25 substance is a catalyst method.

[Claim 21]

A perfluoride processing method according to claim  
19, wherein an acid gas in an exhaust gas after a  
decomposing of a perfluoride substance is removed by  
5 using Ca soft powders or particles

[Claim 22]

A perfluoride processing method according to claim  
21, wherein said Ca soft powders are  $\text{Ca(OH)}_2$ .

10

[Claim 23]

A perfluoride processing method according to claim  
21, wherein under a high temperature condition of more  
than  $200^\circ\text{C}$ , said acid gas in the exhaust gas after the  
15 decomposing of said perfluoride substance and said Ca  
soft powders or particles are reacted.

[Claim 24]

A perfluoride processing method according to claim  
20 21, wherein during a reaction time of said perfluoride  
substance reaction water is added.

[Claim 25]

A perfluoride processing method for use with a  
25 plurality of liquid crystal manufacturing apparatuses

installed within a clean room for receiving  
perfluoride as supplied thereto, characterized by  
comprising the steps of supplying exhaust gases  
containing said perfluoride as drained out of the  
5 liquid crystal manufacturing apparatuses to a  
perfluoride decomposition device installed outside of  
said clean room and then decomposing said perfluoride  
by said perfluoride decomposition device.

10 [Claim 26]

A perfluoride processing method according to claim  
25, wherein a decomposing method of a perfluoride  
substance is a catalyst method.

15 [Claim 27]

A perfluoride processing method according to claim  
25, wherein an acid gas in an exhaust gas after a  
decomposing of a perfluoride substance is removed by  
using Ca soft powders or particles

20

[Claim 28]

A perfluoride processing method according to claim  
25, wherein said Ca soft powders are  $\text{Ca}(\text{OH})_2$ .

25

[Claim 29]

. A perfluoride processing method according to claim  
27, wherein under a high temperature condition of more  
than 200°C, said acid gas in the exhaust gas after the  
5 decomposing of said perfluoride substance and said Ca  
soft powders or particles are reacted.

[Claim 30]

A perfluoride processing method according to claim  
10 27, wherein during a reaction time of said perfluoride  
substance reaction water is added.