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(54) **SEMICONDUCTOR MANUFACTURING DEVICE, SEMICONDUCTOR MANUFACTURING SYSTEM AND SUBSTRATE TREATING METHOD**

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(57) **ABSTRACT**

A semiconductor manufacturing device having a buffer unit which receives a substrate treating substance from an external source, stores it therein, and delivers it to an external unit.

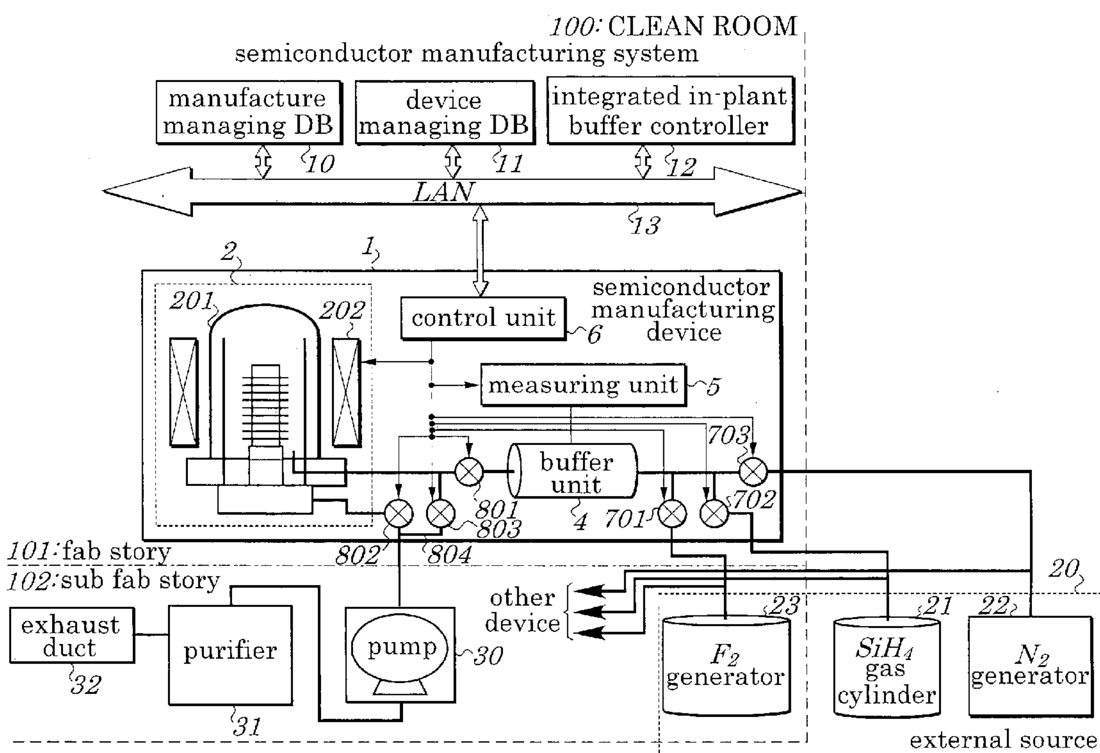


Fig. 1

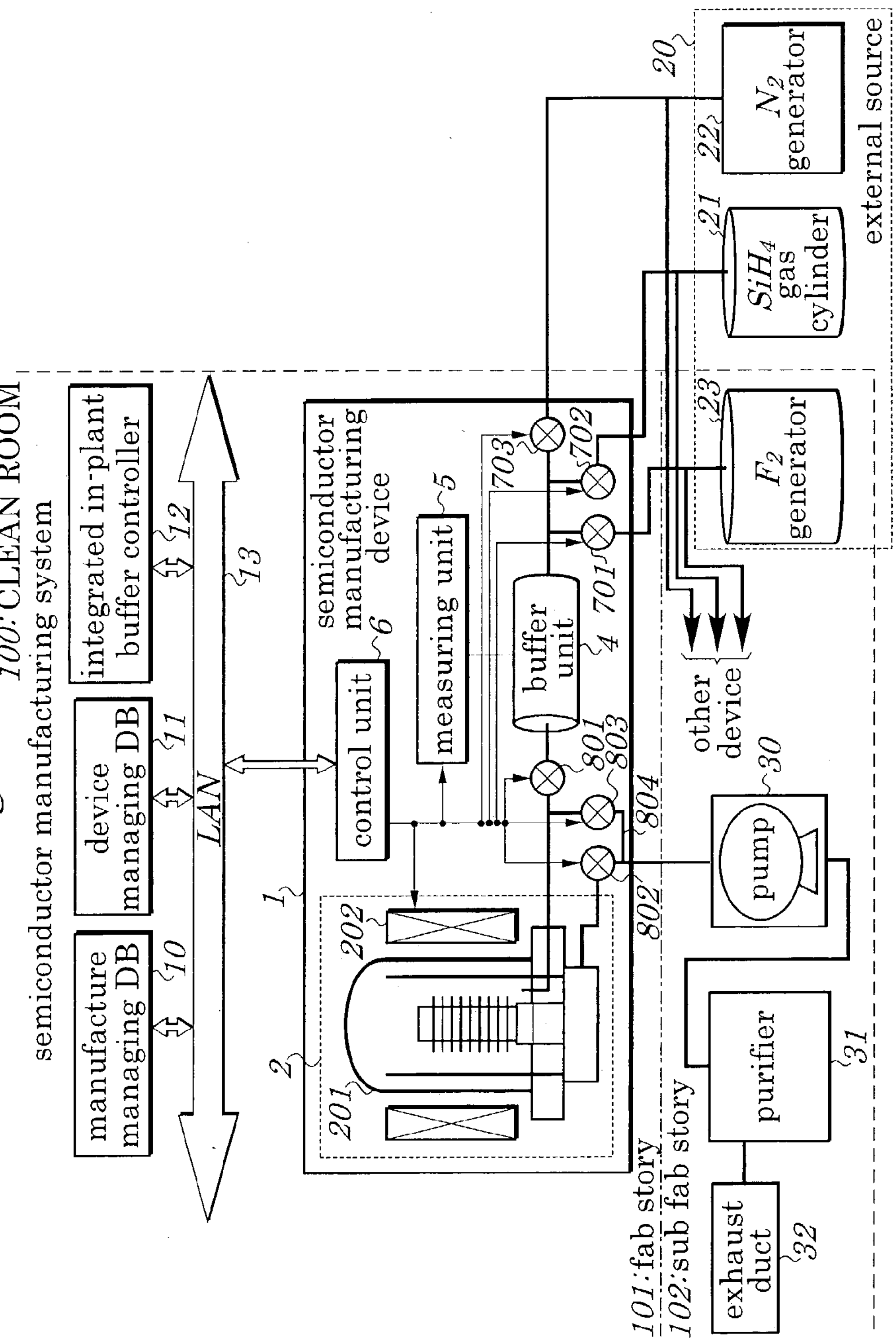

100: CLEAN ROOM
semiconductor manufacturing system
manufacture managing DB
10
device managing DB
11
integrated in-plant buffer controller
12
LAN
13
semiconductor manufacturing device
1
2
201
202
control unit
6
measuring unit
5
buffer unit
4
701
702
703
801
802
803
804
pump
30
purifier
31
exhaust duct
32
101: fab story
102: sub fab story
other device
20
external source
N_2 generator
22
SiH_4 gas cylinder
21
F_2 generator
23

Fig. 2

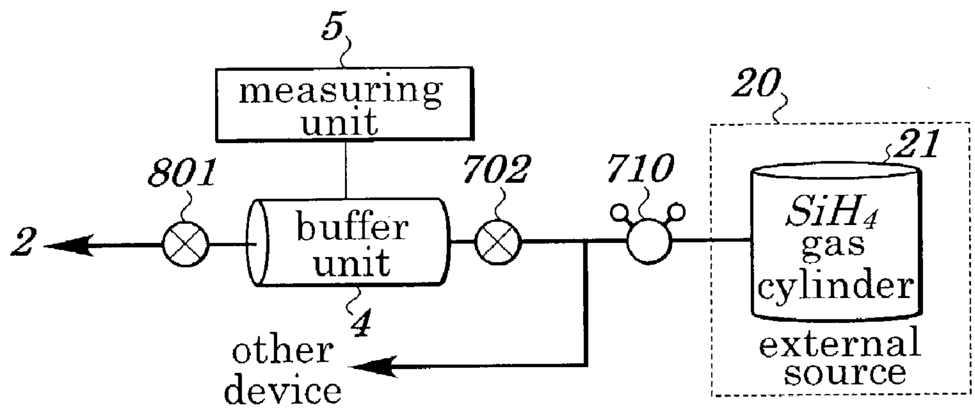


Fig. 3

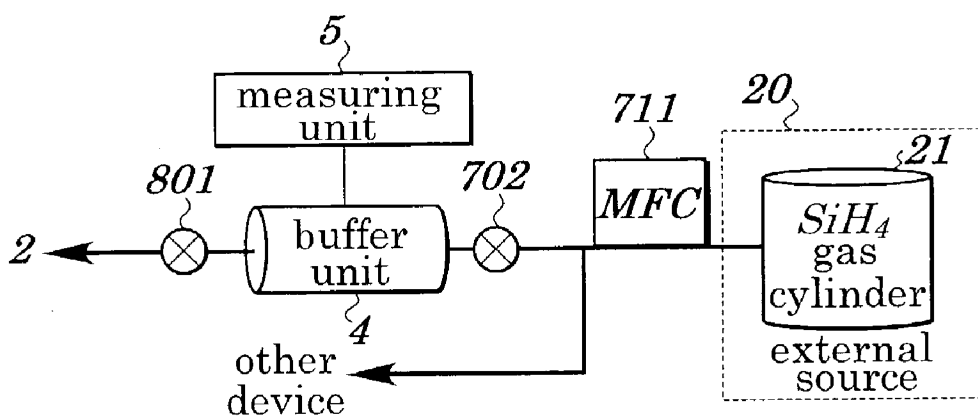


Fig. 4

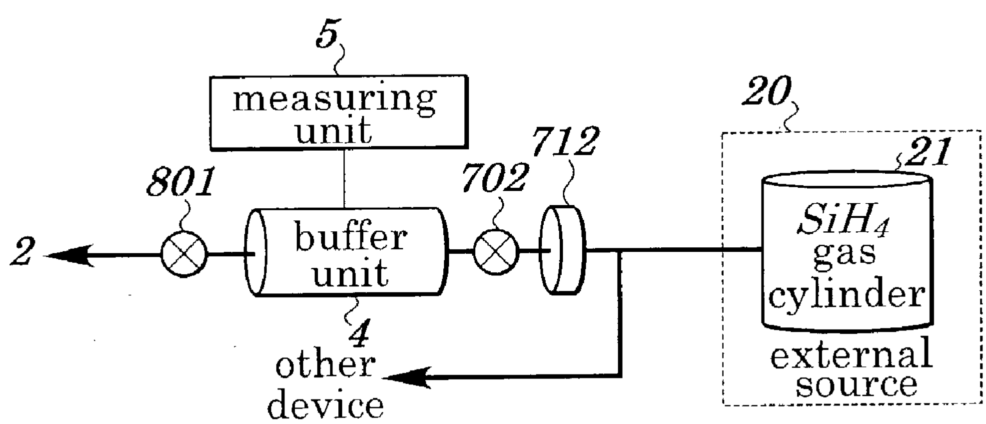


Fig. 5

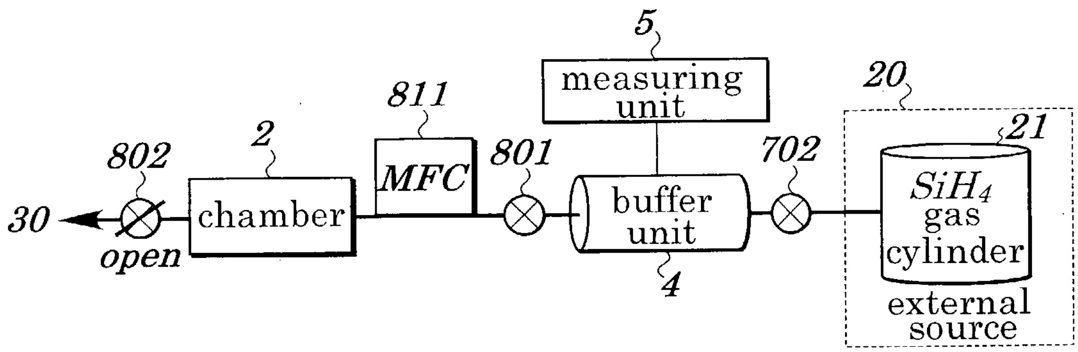


Fig. 6

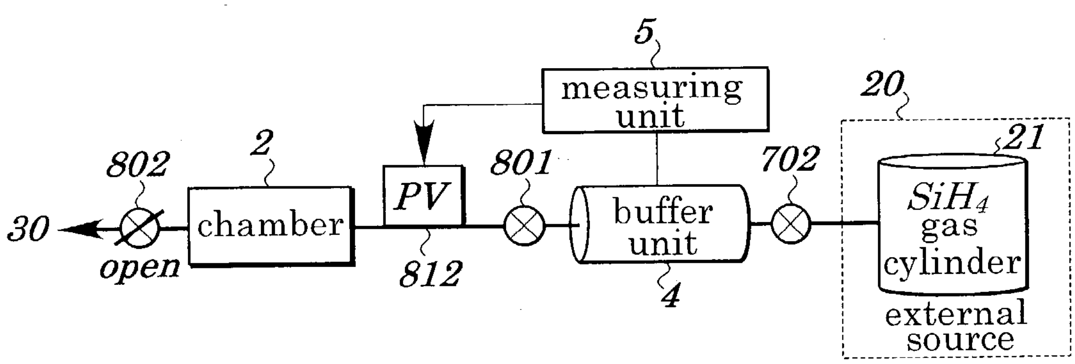


Fig. 7

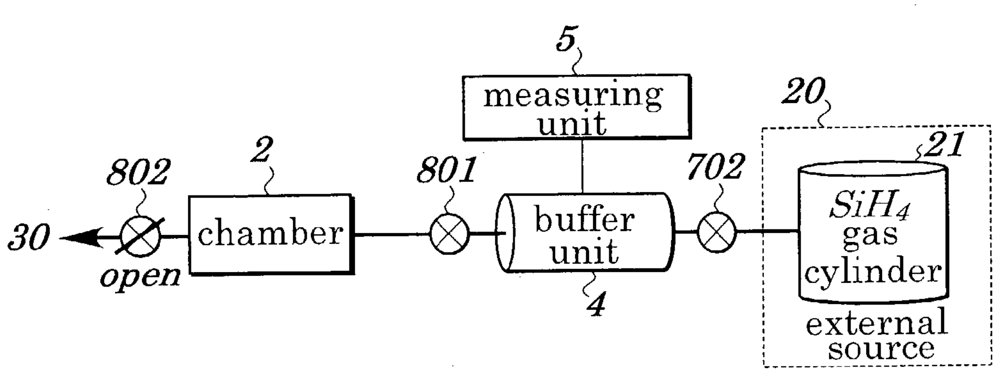


Fig. 8

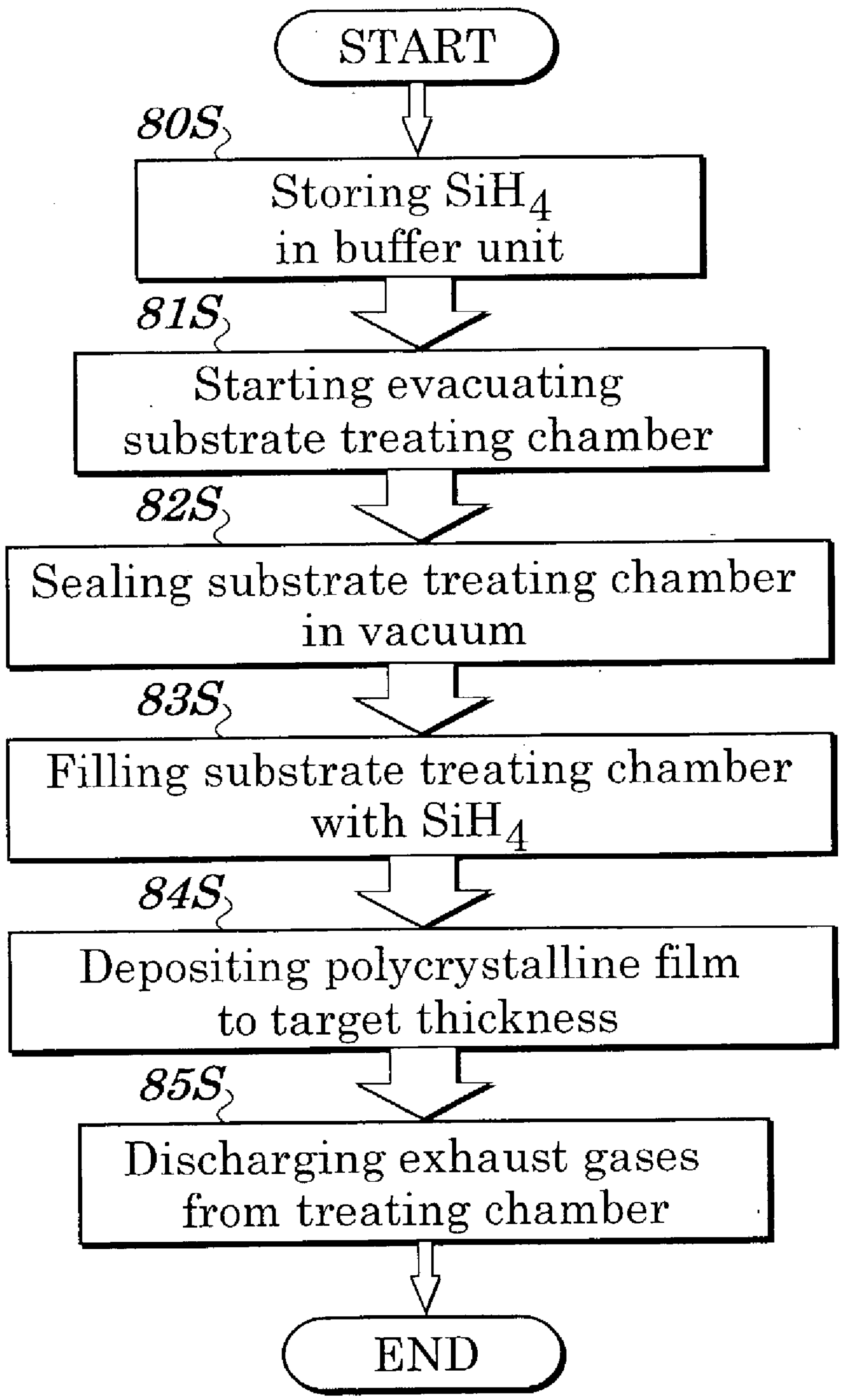

START
80S
Storing SiH_4 in buffer unit
81S
Starting evacuating substrate treating chamber
82S
Sealing substrate treating chamber in vacuum
83S
Filling substrate treating chamber with SiH_4
84S
Depositing polycrystalline film to target thickness
85S
Discharging exhaust gases from treating chamber
END

Fig. 9

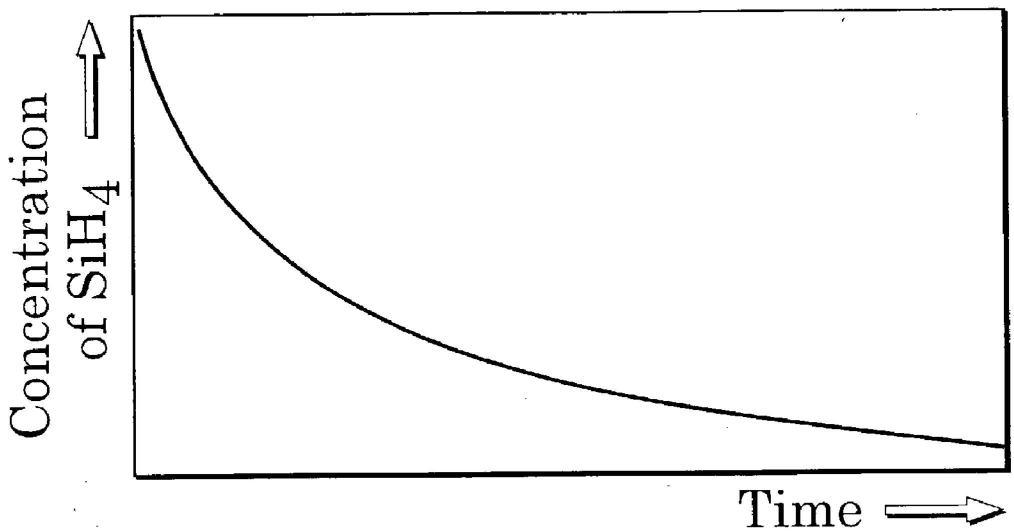

Concentration of SiH_4
Time

Fig. 10

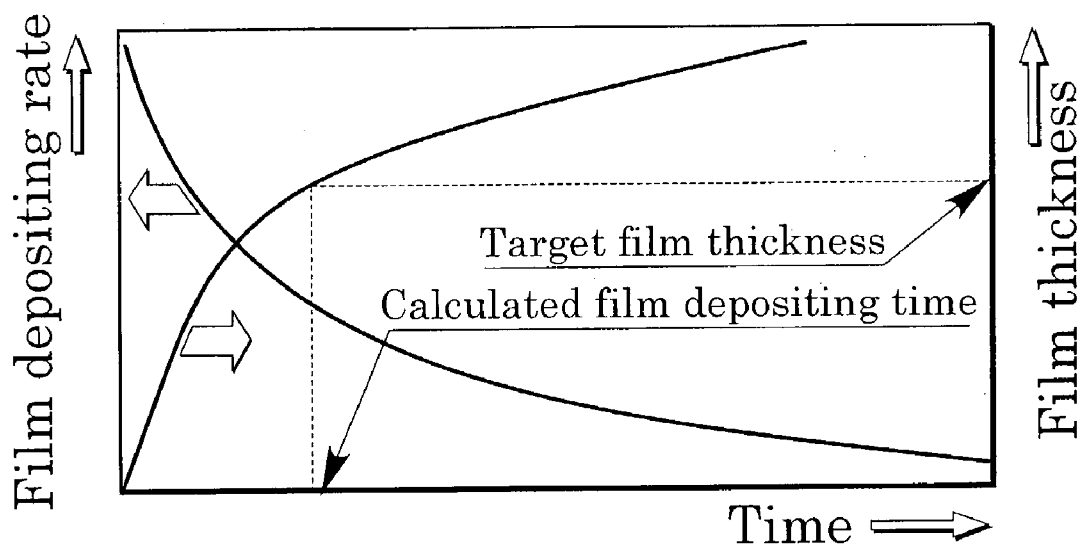

Film depositing rate
Film thickness
Target film thickness
Calculated film depositing time
Time

Fig. 11

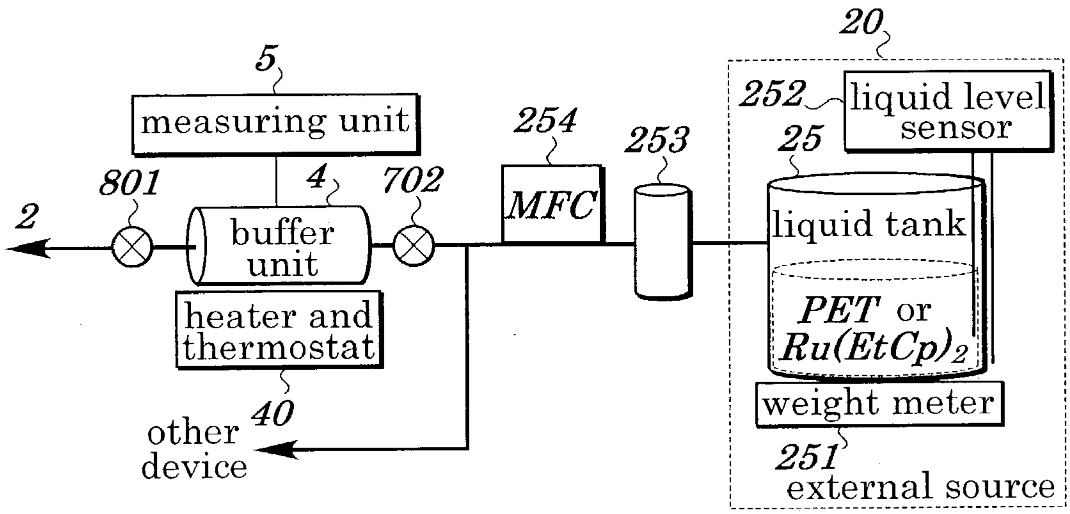

20
252
liquid level sensor
25
5
measuring unit
254
253
801
4
702
MFC
2
buffer unit
liquid tank
PET or
Ru(EtCp)2
heater and thermostat
40
weight meter
other device
251
external source

Fig. 12

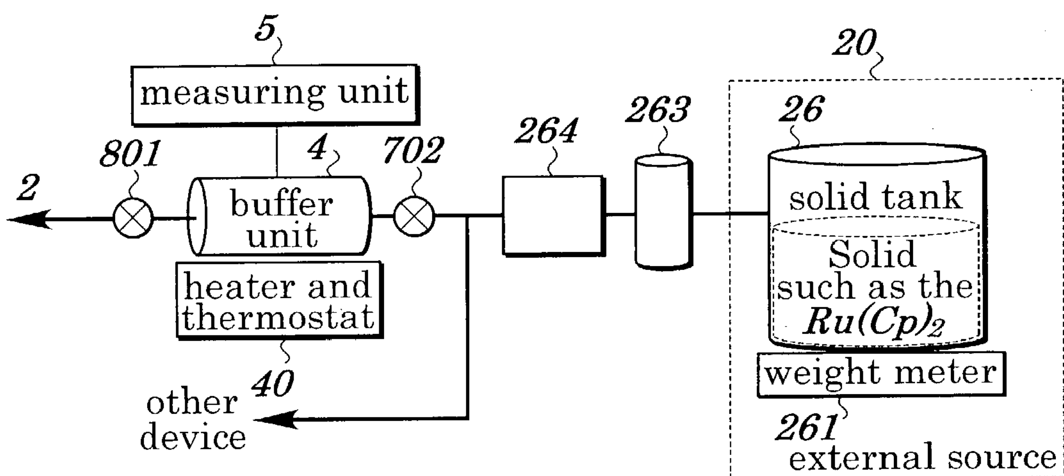

5
20
measuring unit
263
26
264
801
4
702
2
solid tank
buffer unit
Solid such as the Ru(Cp)2
heater and thermostat
40
weight meter
other device
261
external source

Fig. 13

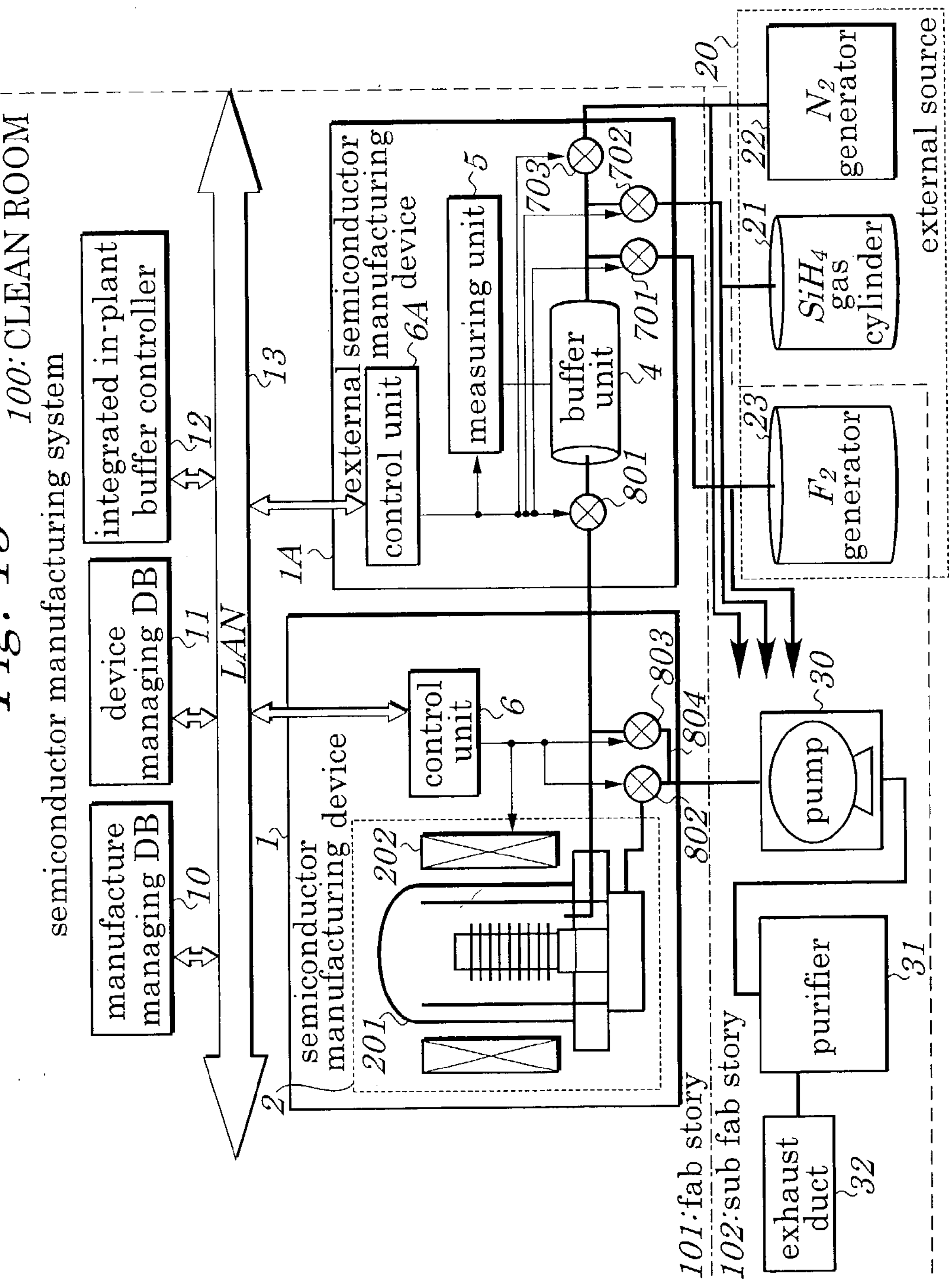
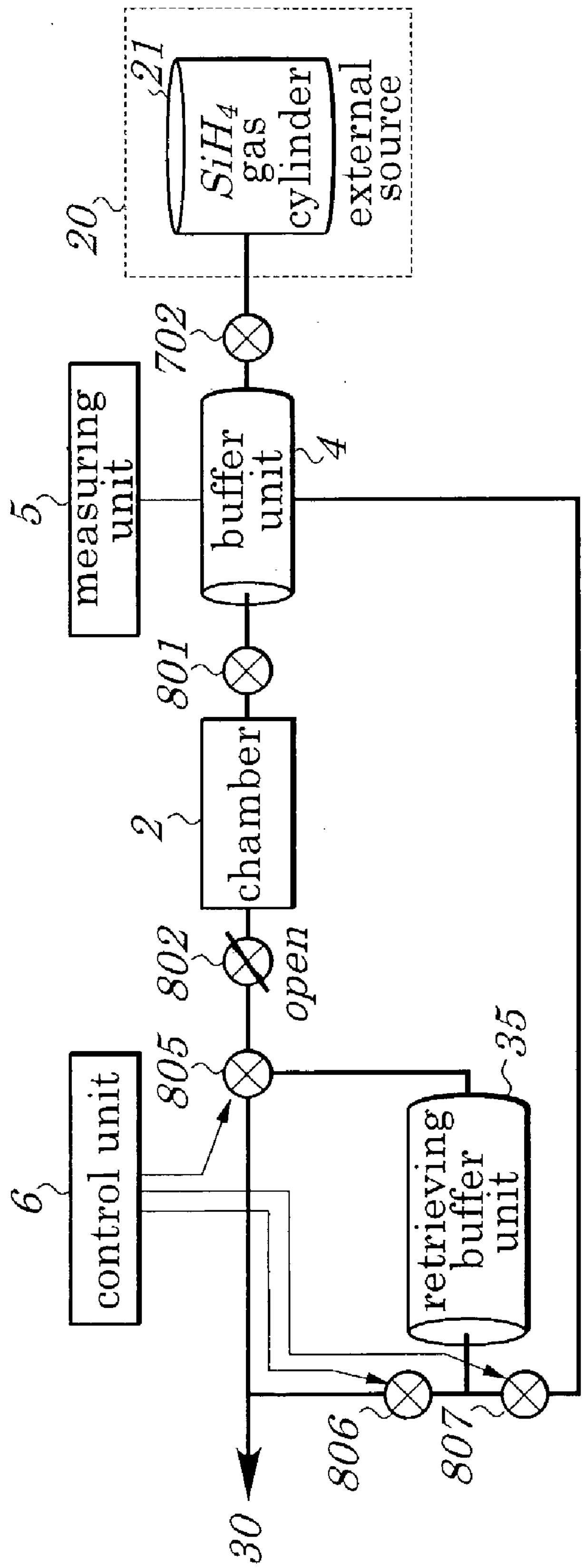
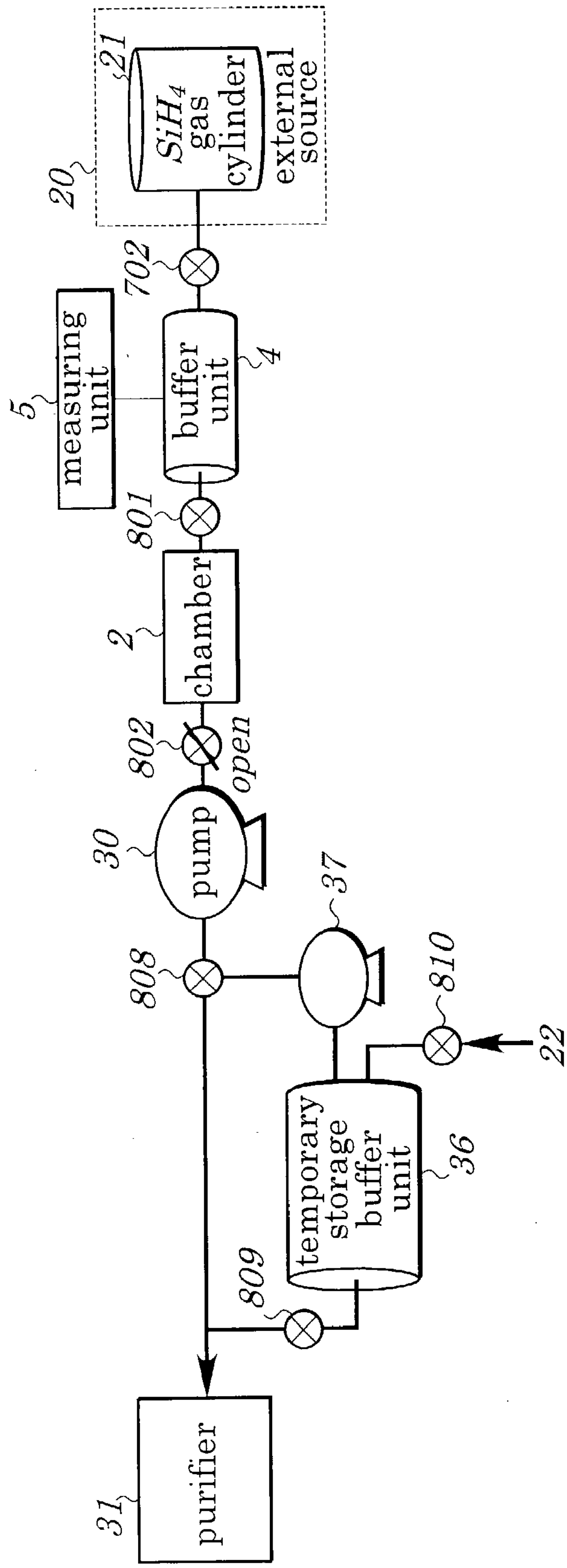

100: CLEAN ROOM
semiconductor manufacturing system
manufacture managing DB
10
device managing DB
11
integrated in-plant buffer controller
12
LAN
13
external semiconductor manufacturing device
1A
control unit
6A
measuring unit
5
buffer unit
4
701
702
703
801
semiconductor manufacturing device
1
2
control unit
6
201
202
802
803
804
101: fab story
102: sub fab story
20
external source
N_2 generator
22
SiH_4 gas cylinder
21
F_2 generator
23
pump
30
purifier
31
exhaust duct
32

Fig. 14



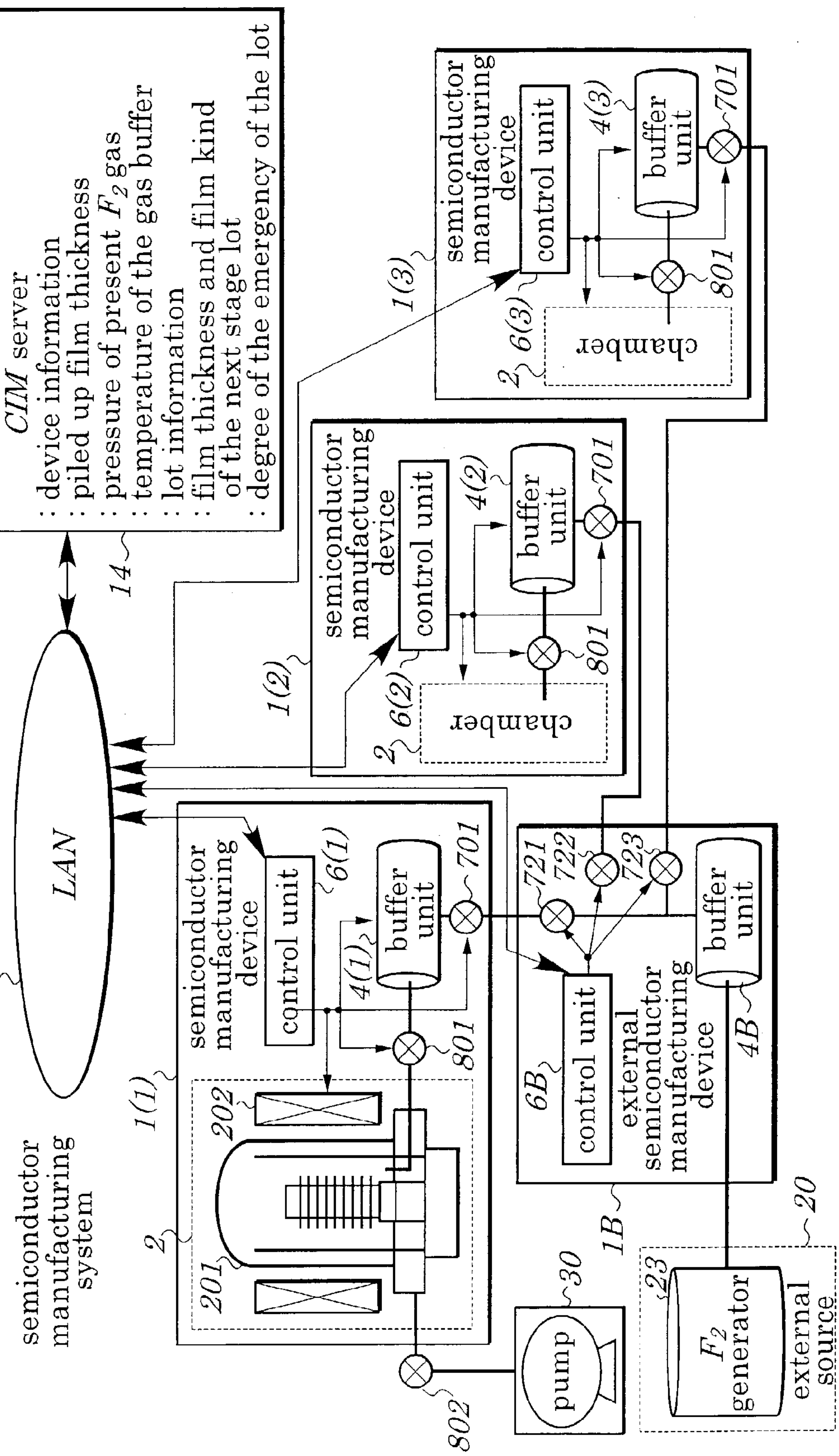
20
21
SiH_4 gas cylinder
external source
702
4
buffer unit
5
measuring unit
801
2
chamber
802
open
805
6
control unit
35
retrieving buffer unit
806
807
30

Fig. 15



20
21
SiH_4 gas cylinder
external source
702
measuring unit
5
buffer unit
4
801
chamber
2
802
open
pump
30
37
808
810
22
temporary storage buffer unit
36
809
purifier
31

Fig. 16



CIM server
: device information
: piled up film thickness
: pressure of present F_2 gas
: temperature of the gas buffer
: lot information
: film thickness and film kind of the next stage lot
: degree of the emergency of the lot
14
13
LAN
semiconductor manufacturing system
1(1)
semiconductor manufacturing device
control unit
6(1)
4(1)
buffer unit
701
801
202
201
2
802
pump
30
1(2)
semiconductor manufacturing device
control unit
6(2)
4(2)
buffer unit
701
801
chamber
2
1(3)
semiconductor manufacturing device
control unit
6(3)
4(3)
buffer unit
701
801
chamber
2
721
722
723
buffer unit
control unit
6B
4B
external semiconductor manufacturing device
1B
20
23
F_2 generator
external source

Fig. 17

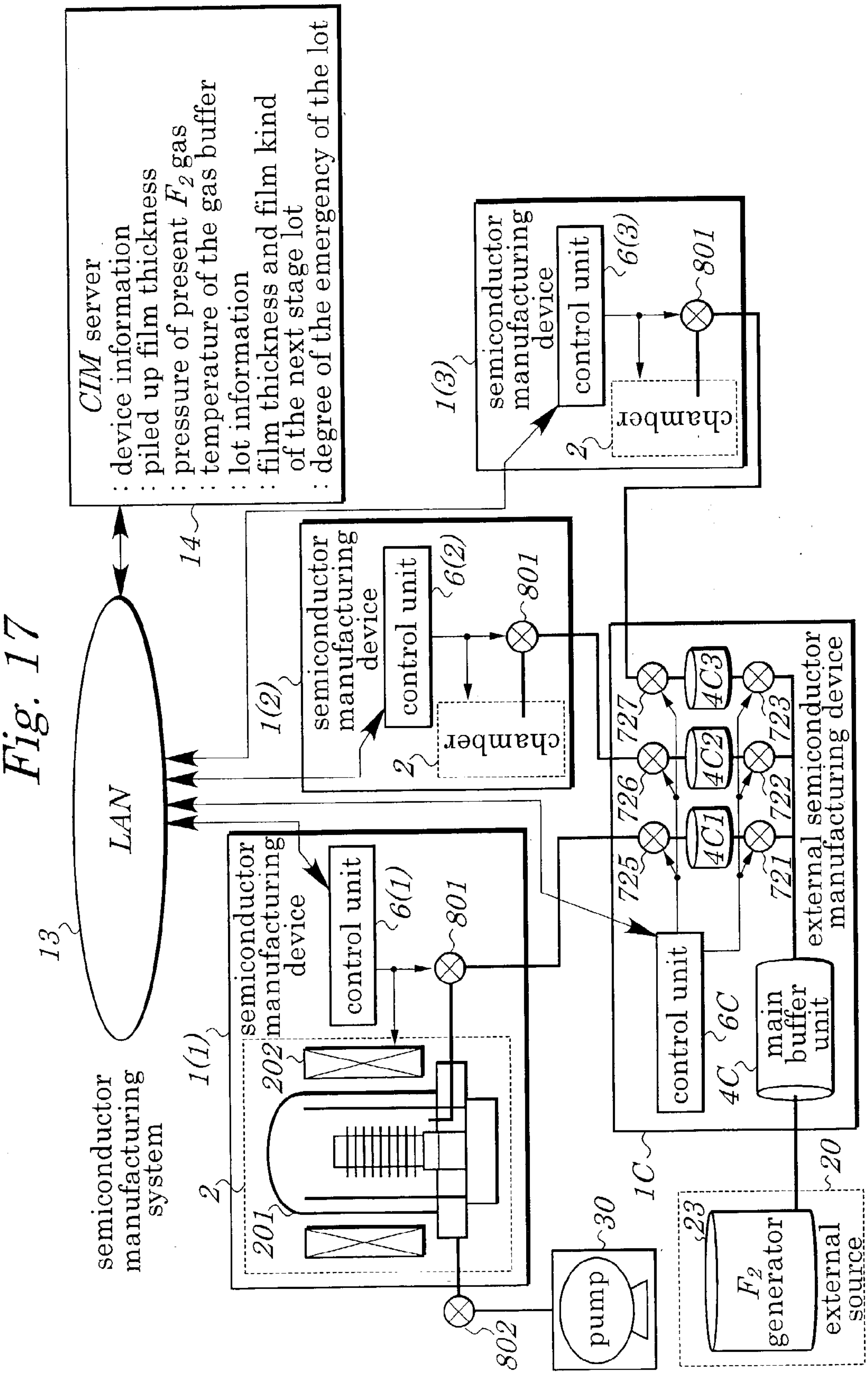
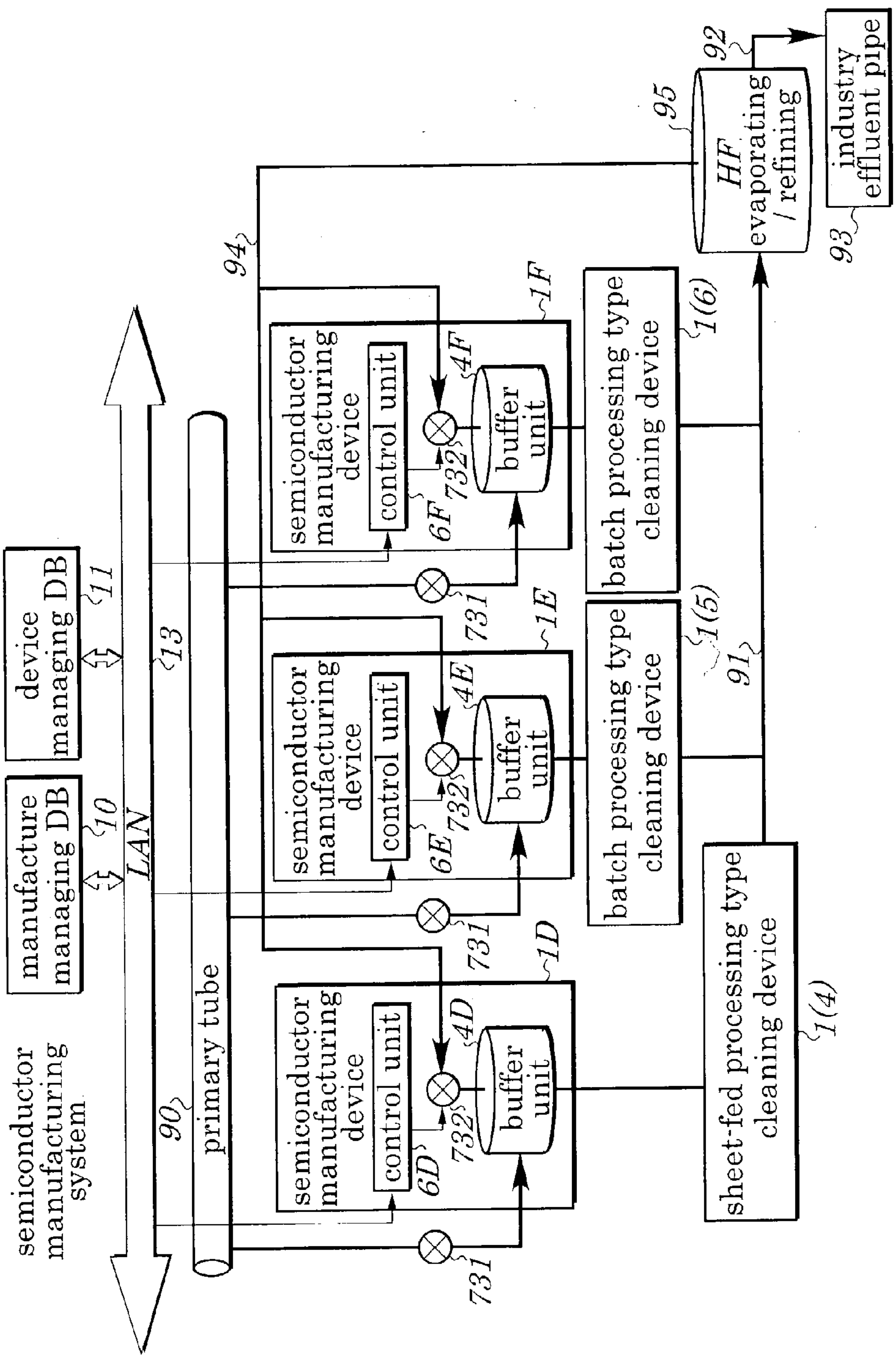

CIM server
: device information
: piled up film thickness
: pressure of present F_2 gas
: temperature of the gas buffer
: lot information
: film thickness and film kind of the next stage lot
: degree of the emergency of the lot
14
LAN
13
semiconductor manufacturing system
1(1)
semiconductor manufacturing device
control unit
6(1)
801
202
201
2
1(2)
semiconductor manufacturing device
control unit
6(2)
chamber
1(3)
semiconductor manufacturing device
control unit
6(3)
chamber
725
726
727
721
722
723
4C1
4C2
4C3
control unit
6C
4C
main buffer unit
external semiconductor manufacturing device
1C
20
23
F_2 generator
external source
pump
30
802

Fig. 18


semiconductor manufacturing system
manufacture managing DB
10
device managing DB
11
LAN
13
90
primary tube
semiconductor manufacturing device
control unit
buffer unit
6D
6E
6F
732
4D
4E
4F
731
1D
1E
1F
94
95
HF evaporating / refining
92
industry effluent pipe
93
batch processing type cleaning device
1(5)
1(6)
91
sheet-fed processing type cleaning device
1(4)

SEMICONDUCTOR MANUFACTURING DEVICE, SEMICONDUCTOR MANUFACTURING SYSTEM AND SUBSTRATE TREATING METHOD

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based on and claims the benefit of priority from the prior Japanese Patent Application No. 2002-073,217 filed on or around Mar. 15, 2002, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a semiconductor manufacturing device, a semiconductor manufacturing system, and a substrate treating method, and more particularly relates to a semiconductor manufacturing device which comprises a source supplying substrate treating substances to a substrate treating chamber, a semiconductor manufacturing system which comprises at least a source supplying substrate treating substances to a substrate treating chamber and a semiconductor manufacturing device, and a substrate treating method applicable to the semiconductor manufacturing device and the semiconductor manufacturing system.

[0004] 2. Description of the Related Art

[0005] A semiconductor manufacturing device uses a variety of substances such as source gases, chemicals, and solvents in a semiconductor manufacturing process. Generally, such substances are supplied from a source which is located near a semiconductor manufacturing plant, and includes cylinder cabinets, gas generators, chemical and solvent tanks, a refiner like an ion exchanger, and so on. The substances are delivered to a semiconductor manufacturing device via gas delivery pipes, or chemical or solvent delivery pipes. The source has a capacity which is sufficient to deliver the substances without any problem.

[0006] Further, the foregoing pipes are large enough to reliably deliver the substances at a required speed.

[0007] The foregoing semiconductor manufacturing device or a semiconductor manufacturing system including such a semiconductor manufacturing device seems to have the following problems.

[0008] The substances such as source gases, chemicals and solvents are not always consumed at the same speed in the semiconductor manufacturing device. For instance, an LPCVD (low pressure chemical vapor deposition) device produces polycrystalline silicon films on a plurality of semiconductor wafers using the LPCVD process of the batch processing type, and requires a mono-silane gas as a source gas only during the formation of polycrystalline silicon films. No source gas is consumed for evacuating substrate treating chambers, and loading or unloading semiconductor wafers to or from a shelf shaped port in the substrate treating chamber even when the LPCVD device is in operation. The capacities of the source or delivery pipes are designed on the basis of feed rates of the source gases which are being consumed. If ten LPCVD devices were provided in the semiconductor manufacturing plant, the source and delivery pipes would be required to have capacities for delivering the source gases to them.

[0009] Further, coolants are also supplied to the LPCVD device in order to cool heaters and pumps, which are used to control temperatures of the substrate treating chambers. A large amount of coolants should be supplied during the operation of the heaters while little coolants are necessary during the non-operation of the heaters.

[0010] Still further, cleaning gases are supplied to the LPVCD device in order to clean the substrate treating chambers, but are required only when the treatment chambers are being cleaned.

[0011] Recently, semiconductor wafers are being enlarged in order to lead better productivity of semiconductors. In response to this trend, a semiconductor manufacturing device, e.g. a substrate treating chamber of an LPCVD device, is also being enlarged, which means increases in source gases, chemicals or solvents to be consumed. Therefore, large sources or delivery pipes are required in order to meet the foregoing requirements, which would lead to large capital investments.

BRIEF SUMMARY OF THE INVENTION

[0012] According to a first feature of the embodiment of the invention, there is provided a semiconductor manufacturing device comprising a buffer unit which receives a substrate treating substance from an external source, stores it therein, and delivers it to an external unit.

[0013] In accordance with a second feature of the embodiment of the invention, there is provided a semiconductor manufacturing device comprising: a substrate treating chamber; and a buffer unit provided in the substrate treating chamber or in the semiconductor manufacturing device, receiving a substrate treating substance from an external source, storing it therein, and delivering it to the substrate treating chamber or the semiconductor manufacturing device for the purpose of treating substrates.

[0014] As a third feature, the embodiment of the invention provides a semiconductor manufacturing system comprising: an external source supplying a substrate treating substance; a semiconductor manufacturing device including a substrate treating chamber; a buffer unit receiving the substrate treating substances from the external source, storing it therein, and delivering it to the substrate treating chamber or the semiconductor manufacturing device; and a control unit controlling the delivery of the substrate treating substances from the external source to the buffer unit and the delivery of the substrate treating substances from the buffer unit to the substrate treating chamber or the semiconductor manufacturing device. The semiconductor manufacturing system further comprises a computer-integrated manufacturing (CIM) system which thoroughly manages the delivery of the substrate treating substances from the external unit, the receipt and storage of the substrate treating substance in the buffer unit, and controls the operations of the semiconductor manufacturing device and the control unit.

[0015] The CIM system includes a record-keeping database which records and manages an in-service schedule of the substance treatment and a manufacture schedule, and controls at least a delivery speed or a delivery order of the substrate treating substances from the external source to the semiconductor manufacturing device via the buffer unit. According to a fourth feature of the embodiment of the invention, there is provided a substrate treating method comprising: receiving a substrate treating substance from an external source, storing in a buffer unit the substrate treating substance necessary for at least one substrate treating process, and delivering a predetermined amount of the substrate treating substance to a substrate treating chamber or a semiconductor manufacturing device provided with a substrate treating chamber.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0016] **FIG. 1** is a block diagram of a semiconductor manufacturing device and a semiconductor manufacturing system according to a first embodiment of the invention.

[0017] **FIG. 2** is a block diagram showing a first control method for loading a substrate treating substance to a buffer unit in the semiconductor manufacturing system of **FIG. 1**.

[0018] **FIG. 3** is a block diagram showing a second control method for loading the substrate treating substance to the buffer unit.

[0019] **FIG. 4** is a block diagram showing a third control method for loading the substrate treating substance to the buffer unit.

[0020] **FIG. 5** is a block diagram showing a first control method for delivering the substrate treating substance to a substrate treating chamber from the buffer unit in the semiconductor manufacturing system of **FIG. 1**.

[0021] **FIG. 6** is a block diagram showing a second control method for delivering the substrate treating substance to the substrate treating chamber from the buffer unit in the semiconductor manufacturing system of **FIG. 1**.

[0022] **FIG. 7** is a block diagram showing a third control method for delivering the substrate treating substance to the substrate treating chamber from the buffer unit in the semiconductor manufacturing system of **FIG. 1**.

[0023] **FIG. 8** is a flow chart showing an operation sequence of the semiconductor manufacturing system of **FIG. 7**.

[0024] **FIG. 9** is a graph showing time-dependent variations of a concentration of a mono-silane gas.

[0025] **FIG. 10** is a graph showing time-dependent variations of deposition rate, thickness and speed of a polycrystalline silicon film on a semiconductor wafer in the semiconductor manufacturing system of **FIG. 7**.

[0026] **FIG. 11** is a block diagram showing a control process for loading a liquid substance to the buffer unit in the semiconductor manufacturing device or semiconductor manufacturing system in the first embodiment.

[0027] **FIG. 12** is a block diagram showing a control process for loading a solid substance to the buffer unit in the semiconductor manufacturing device or semiconductor manufacturing system in the first embodiment.

[0028] **FIG. 13** is a block diagram of a semiconductor manufacturing device or a semiconductor manufacturing system in a second embodiment of the invention.

[0029] **FIG. 14** is a block diagram of a semiconductor manufacturing device or a semiconductor manufacturing system in a first modified example of a third embodiment of the invention.

[0030] **FIG. 15** is a block diagram of a semiconductor manufacturing device or a semiconductor manufacturing system in a second modified example of the third embodiment of the invention.

[0031] **FIG. 16** is a block diagram of a semiconductor manufacturing device or a semiconductor manufacturing system in a fourth embodiment of the invention.

[0032] **FIG. 17** is a block diagram of a semiconductor manufacturing device or a semiconductor manufacturing system in a modified example of the fourth embodiment of the invention.

[0033] **FIG. 18** is a block diagram of a semiconductor manufacturing device or a semiconductor manufacturing system in a fifth embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0034] The invention will be described with reference to embodiments of a semiconductor manufacturing device, a semiconductor manufacturing system, and a substrate treating method shown in the drawings, where like or corresponding parts are denoted by like or corresponding reference numerals.

[0035] (First Embodiment of the Invention)

[0036] This first embodiment of the invention relates to a semiconductor manufacturing device **1** as an LPCVD device, a semiconductor manufacturing system including such a semiconductor manufacturing device, and a substrate treating method applied to them.

[0037] [Basic Structure of Semiconductor Manufacturing Device **1** and Semiconductor Manufacturing System]

[0038] Referring to **FIG. 1**, the semiconductor manufacturing device **1** uses a mono-silane gas as a source gas in order to form polycrystalline silicon films on semiconductor wafers, and includes a substrate treating chamber **2**, and a buffer unit **4** which receives a substrate treating substance from an external source **20**, stores it therein, and delivers it to the substrate treating chamber **2** or to the semiconductor manufacturing device **1**.

[0039] The term "substrate treating" denotes not only forming thin conductive or insulating films on semiconductor wafers (mainly made of a III-V group elements), on glass substrates for a liquid crystal display or the like, on insulating substrates used as wiring substrates, but also etching films. The term "substrate treating substances" refers not only to source gases, liquid chemicals or solvents, granular or solid substances which are directly used for treating substrates, but also to cleaning gases, liquid coolants and so on which are indirectly used for treating the substrates. The external source **20** is provided outside the semiconductor manufacturing device **1** and supplies the substrate treating substances.

[0040] The semiconductor manufacturing device **1** further includes a control unit **6** which controls states of the substrate treating substances in the buffer unit **4**, and a measuring unit **5** which measures the states of the foregoing substances.

[0041] The semiconductor manufacturing device **1** is generally installed at an upper part (fab story) **101** of a clean room **100** in a semiconductor manufacturing plant. The substrate treating chamber **2** includes a reaction tube **201** made of very pure quartz, and a port (without a reference numeral) provided in the reaction tube **201** and receiving substrates such as semiconductor wafers. A heater **202** surrounds the reaction tube **201** in order to control a temperature thereof.

[**0042**] In this embodiment, the buffer unit **4** is housed in the semiconductor manufacturing device **1**, and is positioned between the external source **20** and the substrate treating chamber **2**, receives the substrate treating substances from the external source **20**, stores them therein, and delivers a predetermined amount of them to either the substrate treating chamber **2** or to the semiconductor manufacturing device **1**. The substrate treating substances are intermittently delivered from the external source **20**, and are temporarily stored in the buffer unit **4**. The buffer unit **4** is made of quartz, metal or the like in order to be resistant to the substrate treating substances and pressure and to improve productivity, and is preferably in the shape of a tank having an appropriate capacity.

[**0043**] The external source **20** includes a mono silane gas cylinder **21**, a nitride gas generator **22**, and a fluorine gas generator **23**. The mono-silane gas cylinder **21** and nitride gas generator **23** are provided outside the clean room **100**. The mono-silane gas cylinder **21** supplies a mono-silane gas to the buffer unit **4** via a pneumatic valve **702**. The nitride gas generator **22** supplies a nitride gas to the buffer unit **4** via a pneumatic valve **703**. The nitride gas is used to clean the buffer unit **4** and the substrate treating chamber **2**, and is also used as a dilution gas while the substrate treating substance is reacted. Further, the nitride gas is used in order to return a pressure in the substrate treating chamber **2** to 1×10^5 Pa. The fluorine gas generator **23** is positioned in a sub-fab story **102** under the clean room **100**, and supplies a cleaning gas to the buffer unit **4** via a pneumatic valve **701**. The cleaning gas is used to etch and clean an inner wall of the substrate treating chamber **2** or silicon films on components made of quartz, silicon-carbide and so on.

[**0044**] The buffer unit **4** and the substrate treating chamber **2** are connected by a pneumatic valve **801**, through which the mono-silane gas, nitride gas or fluorine gas is delivered to the substrate treating chamber **2** from the buffer unit **4**.

[**0045**] The measuring unit **5** of the semiconductor manufacturing device **1** is a pressure gauge, for instance, is connected to the buffer unit **4**, and measures a pressure (states) of the substrate treating substance in the buffer unit **4**.

[**0046**] For instance, the mono-silane gas in the substrate treating chamber **2** is heated by a heater **202** in order to form a polycrystalline silicon film on a semiconductor wafer using the LPCVD reaction. The fluorine gas cleans the inner wall of the substrate treating chamber **2** by the etching reaction. After the LPCVD or etching reaction, reacted gases or non-used gases are discharged by a vacuum exhaust pump **30** via a gate valve **802**.

[**0047**] The gate valve **802** opens and closes in order to adjust a fluid conductance in the substrate treating chamber **2**, and also interrupts the gas. The vacuum exhaust pump **30** is positioned in the sub-fab story **102** in the cleaning room **100**. An exhaust gas from the vacuum exhaust pump **30** is purified in a purifier **31**, and is discharged to the outside via an exhaust duct **32** in the sub-fib story **102**.

[**0048**] The control unit **6** controls the operations of the heater **202**, measuring unit **5**, pneumatic valves **701** to **703** and **801**, and gate valve **802**, which means that the control unit **6** controls the whole operations of the semiconductor manufacturing device **1**

[**0049**] Specifically, the control unit **6** is connected to a manufacture managing database **10** which manages data of the LPCVD process, to a device managing database **11** which manages the operations of the semiconductor manufacturing device **1**, and to a an integrated in-plant buffer controller **12**. The control unit **6** is in connection with the manufacture managing database **10** and the device managing database **11** via a local area network (called the "LAN") **13** of the computer-integrated manufacture control system (called the "CIM system"). The control unit **6** receives outputs from a pressure gauge (not shown) and heater **202** in the substrate treating chamber **2**, i.e. measured values such as a furnace pressure and temperature of the substrate treating chamber **2**. The control unit **6** transfers film depositing information to the manufacture managing database **10** via the LAN **13**.

[**0050**] The semiconductor manufacturing system is constituted by: the semiconductor manufacturing device **1** which includes at least the external source **20** supplying the substrate treating substances and the substrate treating chamber **2**; the buffer unit **4** which receives the substance treating substance from the external source **20**, stores it therein, and delivers it to either the substrate treating chamber **2** or the semiconductor manufacturing device **1**; and the control unit **6** which controls the delivery of the substrate treating substances between the external source **20** and the buffer unit **4**, and between the buffer unit **4** and the substrate treating chamber **2** or the semiconductor manufacturing device **1**.

[**0051**] [Operation of Semiconductor Manufacturing Device **1** and Semiconductor Manufacturing System, and Substrate Treating Method]

[**0052**] A polycrystalline silicon film will be deposited on a semiconductor wafer as described hereinafter by the semiconductor manufacturing device **1** and the semiconductor manufacturing system. In this case, the substrate is treated using the LPCVD process.

[**0053**] (1) First of all, the following LPCVD process data are input into the control unit **6** from the manufacture managing database **10** via the LAN **13**, which is performed before raw semiconductor wafers are delivered to the semiconductor manufacturing device **1**.

[**0054**] a. thickness of the polycrystalline silicon film: 100 nm

[**0055**] b. film depositing temperature: 620° C.

[**0056**] c. feed rate of mono-silane gas: 100 sccm

[**0057**] d. film depositing pressure: 26.6 Pa

[**0058**] e. film depositing period: 10 minutes

[0059] A total amount of the mono-silane gas to be used is expressed by the following formula.

100 sccm×10 minutes 1000 scc (i.e. a volume of 1000 cm^3

[0060] under a standard state of a gas)

[0061] In this case, the buffer unit **4** has a 1000 scc capacity, for instance.

[0062] (2) The control unit **6** opens the gate valve **802** once in accordance with the received data, thereby evacuating the substrate treating chamber **2** to a sufficiently low pressure using the vacuum exhaust pump **30**.

[0063] (3) Thereafter, the control unit **6** closes the gate valve **802**, and opens the pneumatic valve **702**, so that the mono-silane gas will be delivered to the buffer unit **4** from the mono-silane gas cylinder **21**. When the buffer unit **4** is filled with the 1000 scc mono-silane gas, the control unit **6** closes the pneumatic valve **702**. Therefore, the buffer unit **4** is sealed, thereby temporarily storing the mono-silane gas.

[0064] The mono-silane gas is filled into the buffer unit **4** by any of the following control methods shown in **FIG. 2** to **FIG. 4**.

[0065] According to a first control method shown in **FIG. 2, a** pressure regulator **710** is provided between the mono-silane gas cylinder **21** and the buffer unit **4**, and in front of (or behind) the pneumatic valve **702**, and automatically adjusts an amount of the mono-silane gas to be supplied to the buffer unit **4** in response to a command from the control unit **6**. The pressure regulator **710** is preferably a pressure control valve, and maintains a pressure of the mono-silane gas at 26.6 Pa, which allows the buffer unit **4** to store the mono-silane gas in the amount of 1000 scc.

[0066] With a second control method shown in **FIG. 3**, the amount of the mono-silane gas to be supplied is controlled on the basis of a feed rate and a feed period thereof. A mass flow controller **711** is positioned between the mono-silane gas cylinder **21** and the buffer unit **4** and in front of (or behind) the pneumatic valve **702**, and controls the amount of the mono-silane gas to the buffer unit **4**. When the mono-silane gas is supplied for 30 seconds at the feed rate of 2 slm, the buffer unit **4** is filled with 1000 scc mono-silane gas. Further, if an inexpensive mass flow meter is used in place of the mass flow controller **711**, the 1000 scc mono-silane gas to the buffer unit **4** can be controlled on the basis of integrated output values of the mass flow meter. According to a third control method of **FIG. 4**, the amount of the mono-silane gas is controlled on the basis of a pressure measured by the measuring unit **5** attached to the buffer unit **4**. When the measured pressure becomes equal to a predetermined value, the control unit **6** closes the pneumatic valve **702**, thereby controlling the amount of the mono-silane gas in the buffer unit **4**. If the pressure of the mono-silane gas quickly increases, a conductance regulator **712** is preferably provided in front of the pneumatic valve **702** in order to feed-back control the amount of the mono silane gas on the basis of the measured pressure thereof. The conductance regulator **712** may be an orifice, a piezzo valve or the like which opens or closes in order to adjust a conductance.

[0067] The pressure regulator **710**, mass flow controller **711** or conductance regulator **712** which is rather expensive can be used in common for a plurality of the semiconductor manufacturing devices **1** when it is positioned in front of them, i.e. just behind the mono-silane gas cylinder **21**.

[0068] No mass flow controller **711** (or no mass flow meter) is employed in the first and third control methods (shown in **FIG. 2** and **FIG. 4**, respectively). However, since the inner capacity of the buffer unit **4** is constant in these control methods, the amount of mono-silane gas to be loaded can be precisely controlled by accurately measuring the temperature and pressure of the buffer unit **4** in which the mono-silane gas is to be used in an optimum state. In such a case, no flow rate of the mono-silane gas is required to be measured. The semiconductor manufacturing device **1** or the semiconductor manufacturing system can adopt any of or any combination of the first to third control methods in order to obtain products (e.g. semiconductor devices) which satisfy required specifications, have reasonable cost and so on.

[0069] In the semiconductor manufacturing device **1** or the semiconductor manufacturing system including the buffer unit **4**, the mono-silane gas is quickly supplied to and stored in the buffer unit **4** regardless of an actual period for forming the polycrystalline silicon film. It is possible to shorten the time period during which the semiconductor manufacturing device **1** is in connection with the external source **20**. Further, the buffer unit **4** stores the mono-silane gas before the film forming process is started in the substrate treating chamber **2**, so that it is possible to remarkably reduce a chance in which the film forming process is interrupted due to an accident or malfunction of the semiconductor manufacturing system (in the semiconductor manufacturing plant), interruption or reduction of the mono silane gas due to man-caused errors, and so on. This means that the polycrystalline silicon films can be more reliably and efficiently formed.

[0070] Further, the mono-silane gas can be delivered to and stored in the buffer unit **4** longer than the film depositing period. This is effective in downsizing the facilities for supplying and delivering the mono-silane gas, (e.g. delivery pipes may be made thin), and in extensively reducing the cost of the foregoing facilities. The necessary cost can be drastically decreased for supply and delivery.

[0071] (4) While the mono-silane gas is being filled and stored in the buffer unit **4**, semiconductor wafers are conveyed into the substrate treating chamber **2** which has been evacuated for the purpose of film deposition. The substrate treating chamber **2** has its temperature adjusted to 620° C. by the heater **202**, and the pressure thereof adjusted to 26.6 Pa by the vacuum exhaust pump **30**.

[0072] Referring to **FIG. 5**, the mass flow controller **811** is provided between the pneumatic valve **801** and the substrate treating chamber **2**, i.e. behind the buffer unit **4**, thereby regulating a feed rate of the mono-silane gas to the substrate treating chamber **2** from the buffer unit **4**.

[0073] When the conductance regulator **812** is positioned behind the buffer unit **4** (as shown in **FIG. 6**) and is used together with the pneumatic valve **801**, the feed rate of the mono-silane gas can be regulated without using the mass flow controller **811**. The conductance regulator **812** may be preferably an orifice, a piezzo valve or the like. The conductance regulator **812** regulates the feed rate of the mono-silane gas such that the mono-silane gas is reduced at the rate of 1×10^4 Pa/min where the output of the measuring unit **5** (e.g. a pressure value) uniformly decreases. This is because the mono-silane gas having the pressure of 1×10^5 Pa is completely consumed for 10 minutes.

[0074] Therefore, it is not necessary to precisely measure the 1000 scc mono-silane gas used for the film deposition prior to the manufacturing process.

[0075] (5) A polycrystalline silicon film is formed under the conditions of 100 sccm and 10 minutes. After the film deposition, the mono-silane gas remaining in the buffer unit **4** is directly discharged to the vacuum exhaust pump **30** via a bi-path line **804** which is opened or closed by a valve **803** but without via the substrate treating chamber **2**. Otherwise, the mono-silane gas in the buffer unit **4** is stored for the next following film deposition.

[0076] (6) The mono-silane gas and so on discharged by the vacuum exhaust pump **30** are purified by the purifier **31**, and are sent to an exhaust duct **32**.

[0077] After the foregoing LPCVD process, the polycrystalline silicon film is completed on the semiconductor wafer.

[0078] [Application to Batch Processing]

[0079] The invention is applicable to a batch processing in which 100 to 200 semiconductor wafers, for instance, are placed in the substrate treating chamber **2** and on which polycrystalline silicon films are formed using the semiconductor manufacturing device **1** (LPCVD device).

[0080] In the batch processing, semiconductor wafers are vertically placed, with 5 mm spaces kept therebetween, in a vertical substrate treating chamber **2** (a vertical LPCVD furnace) of the semiconductor manufacturing device **1**. The substrate treating chamber **2** is heated to a reaction temperature of 620° C., for example, and becomes stable. The mono-silane gas whose feed rate has been controlled by the mass flow controller or the like is supplied to the substrate treating chamber **2**. However, the mono silane gas is consumed at an upper part of the substrate treating chamber **2**, and a reaction gas is generated, so that the mono-silane gas may be diluted at a lower part of the substrate treating chamber **2**. This means that film deposition will be slowed down. Specifically, the mono-silane gas is consumed by the deposition or vapor reaction as expressed by the following reaction formula, and silylene gas (SiH_2) or a hydrogen gas (H_2) is generated. As a result, a partial pressure of the mono-silane gas (SiH_4) is reduced, so that the deposition speed is reduced.

[0081] $SiH_4 \rightarrow SiH_2+H_2$ (vapor reaction)

[0082] $SiH_4 \rightarrow Si+2H_2$ (deposition reaction)

[0083] $SiH_2 \rightarrow Si+H_2$ (deposition reaction)

[0084] When the mono-silane gas is continuously supplied to the substrate treating chamber **2** at the predetermined feed rate, e.g. 100 sccm, film deposition on semiconductor wafers at the lower part of the substrate treating chamber **2** will be slowed down for the foregoing reasons. The vertical spaces between the semiconductor wafers are small, i.e. 5 mm, compared with a diameter thereof. The mono-silane gas is diffused toward the centers of the semiconductor wafers via peripheral areas thereof. In each semiconductor wafer, the peripheral area is an upstream while the center is a downstream. Therefore, the polycrystalline silicon film is quickly formed at the upstream compared with at the downstream, and is thin at the downstream.

[0085] In the first embodiment, the feed rate of the mono-silane gas to the buffer unit **4** is controlled by the mass flow controller **811** (shown in **FIG. 5**) or by the conductance regulator **812** (shown in **FIG. 6**), which enables the polycrystalline silicon films to be uniformly deposited. Further, the amount of the mono-silane gas used for the film deposition can be controlled on the basis of a total amount thereof supplied to the substrate treating chamber **2** from the buffer unit **4**, so that the polycrystalline silicon films will have the uniform thickness. In this case, the feed rate of the mono-silane gas is not controlled at all as shown in **FIG. 7**.

[0086] **FIG. 8** is the flow chart showing the sequence of the LPCVD process for which the gas source of **FIG. 7** is utilized.

[0087] (1) First of all, the mono-silane gas is delivered to the buffer unit **4** from the mono-silane gas cylinder **21** of the external source **20**. The buffer unit **4** temporarily stores the mono-silane gas (step **S80**). The amount of the mono-silane gas is measured in order that the buffer unit **4** stores a predetermined amount thereof.

[0088] The presence of the buffer unit **4** is effective in reducing a difference between the time when the mono-silane gas is required and the time to supply the gas. This is effective in preventing the gas source from having an excessively large capacity, and in reducing costs of the gas source and delivering facilities. Further, the mono-silane gas is controlled on the basis of the total amount thereof in place of the feed rate thereof, which is effective in promoting quick supply of the mono-silane gas, in controlling the vaporization of solids or liquids, and in enabling supply of intermediate precursors and so on in response the chemical reaction.

[0089] (2) The gate valve **802** is opened in order to sufficiently evacuate the substrate treating chamber **2** using the vacuum exhaust pump **30** (step **S81**).

[0090] (3) When the pressure of the substrate treating chamber **2** is lowered to 0.133 Pa, for example, the gate valve **802** is completely closed, thereby sealing the substrate treating chamber **2** (step **S82**).

[0091] (4) The pneumatic valve **801** between the substrate treating chamber **2** and the buffer unit **4** is fully opened, thereby filling the substrate treating chamber **2** with the target amount of the mono-silane gas in several seconds (step **S83**). Therefore, the mono-silane gas can be quickly filled in and diffused throughout the narrow spaces between the semiconductor wafers in the substrate treating chamber **2** compared with the reaction speed thereof. In other words, it is possible to reduce chances in which deposited films are non-uniform due to a diffusion-limit of the mono-silane gas. As a result, the polycrystalline silicon films can have a uniform thickness.

[0092] When the external source of **FIG. 7** is used, the concentration of the mono-silane gas reduces as polycrystalline silicon films are being deposited as shown in **FIG. 9**. Further, a film deposition rate varies with the time as shown in **FIG. 10**. These differ from the case where the supply amount of the mono-silane gas is controlled by the mass flow controller or the like. However, the target film thickness is derived by integrating the film deposition data, so that the film deposition period can be determined on the target film thickness. Referring to **FIG. 10**, the film deposition rate is large immediately after the start of the film deposition, becomes smaller with the lapse of time, and gradually is stabilized as the target thickness is attained. Therefore, the polycrystalline silicon films can be formed as reliably and quickly as possible, and have the uniform thickness.

[**0093**] (5) The film deposition is carried out until the target thickness is accomplished (step **S84**).

[**0094**] (6) The gate valve **802** is fully opened after the deposited films have the target thickness, so that non-used mono-silane gas and so on are discharged from the substrate treating chamber **2** by the vacuum exhaust pump **30**. In this state, the film deposition will be completed (step **S85**).

[**0095**] [Application to Deposition of Doped Silicon Film]

[**0096**] The foregoing semiconductor manufacturing device **1** or semiconductor manufacturing system is also applicable to the deposition of polycrystalline (or single crystal) silicon films which are doped with impurities such as arsenic (As), boron (B), phosphor (P), impurities such as germanium (Ge) of the IV group element similarly to silicon or the like. These impurities are used as donors or acceptors, and are doped into films being deposited.

[**0097**] The semiconductor manufacturing device **1** or semiconductor manufacturing system also includes another buffer unit (which is similar to the buffer unit **4** for the mono-silane gas, but is not shown) in order to store impurities and to obtain doped polycrystalline silicon films. This buffer unit stores source gases such as an arsine gas (AsH_3), a diborane gas (B_2H_6), a phosphine gas (PH_3), a germane gas (GeH_4) or the like which are used as dopants. The source gases are supplied to the substrate treating chamber **2** similarly to the mono-silane gas, thereby easily obtaining doped polycrystalline silicon films.

[**0098**] Alternatively, both the mono-silane gas and the foregoing source gases (e.g. arsine gas and so on) may be mixed and stored together in the buffer unit **4**. The dopants can be controlled in order to have a uniform concentration before they are delivered to the buffer unit **4**.

[**0099**] In the foregoing case, the measuring unit **5** is further provided with a mass spectrograph, an infrared absorption spectrograph and so on, analyzes the gases stored in the buffer unit **4**, and outputs analyzed results to the CIM system. Therefore, it is possible to precisely detect concentrations of the mixed gases prior to the film deposition. Further, the concentration and amount of the mono-silane gas and source gases to the buffer unit **4** can be easily controlled by operating the pneumatic valve **702** and so on which control the feed rates of the gases.

[**0100**] Still further, even when the measuring unit **5** includes only a pressure gauge, mixing ratios of the mono-silane gas and source gases can be easily calculated by measuring pressure increases thereof using the pressure gauge when these gases are stored in the buffer unit **4**.

[**0101**] Both non-doped and doped polycrystalline silicon films are made in the identical manner regardless of the methods for storing the mixed gases in the buffer unit **4**.

[**0102**] [Application to Making Insulating Film: Liquid Source]

[**0103**] The semiconductor manufacturing device **1** or the semiconductor manufacturing system is still further applicable to making insulating films. The following describe how a tantalum oxide film is made using the LPCVD process.

[**0104**] Referring to **FIG. 11**, the external source **20** is provided with a liquid tank **25** where penta ethoxyl tantalum (called the "PET") is stored. The PET is a liquid at normal pressures and normal temperatures. An amount of the PET necessary for the substrate treatment is measured and controlled at least by a weight meter **251**, a liquid level gauge **252**, a liquid scale **253**, or the mass flow controller (MFC) **254**. The PET is delivered to the buffer unit **4**.

[**0105**] The buffer unit **4** further includes a heater and a thermostat **40**. The PET delivered to the buffer unit **4** is heated by the heater under the control of the thermostat **40**, is vaporized in a state where it does not thermally react, is changed to a gas, and is stored in the buffer unit **4**.

[**0106**] The PET is delivered to the substrate treating chamber **2** from the buffer unit **4**, and is used to obtain the tantalum oxide film using the LPCVD process. Since the semiconductor manufacturing device **1** or the semiconductor manufacturing system includes the buffer unit **4**, the substrate treating substance can be reliably supplied without any problem caused by a reduced capacity of a vaporizer or the like in response to the vapor phase LPCVD reaction of the PET which is liquid at the normal pressures and temperatures. Further, the necessary amount of source gases can be reliably supplied for forming tantalum oxide films.

[**0107**] [Application to Making Metal Film: Solid and Liquid Sources]

[**0108**] The semiconductor manufacturing device **1** or the semiconductor manufacturing system is also applicable to forming metal films (e.g. platinum films). The following describe how ruthenium films are made by the LPCVD process.

[**0109**] Referring to **FIG. 12**, the external source **20** includes a solid tank **26** storing ruthenium cyclopentane (Ru(Cp)2) powders, grains or pellets at the normal pressures and temperatures. A necessary amount of the ruthenium cyclopentane is supplied to the buffer unit **4**. For this purpose, at least a weight and weighing capacity of ruthenium cyclopentane are measured by a weightometer **261** and a weighing scale **263**, respectively , or the number of powders, grains or pellets thereof is counted by a counter **264**.

[**0110**] The buffer unit **4** includes a heater and a thermostat **40** which are similar to those shown in **FIG. 11**. The ruthenium cyclopentane is vaporized by the heater and thermostat **40** in the buffer unit **4**, and is stored therein.

[**0111**] The stored ruthenium cyclopentane is delivered to the substrate treating chamber **2**, so that a ruthenium film can be formed by the LPCVD process similarly to the polycrystalline silicon film using the mono-silane gas.

[**0112**] The semiconductor manufacturing device **1** or the semiconductor manufacturing system includes the buffer unit **4**, so that the solid substrate treating substance

(Ru(Cp)2) can be reliably supplied without any problem caused by a reduced capacity of a vaporizer or the like in response to the vapor phase LPCVD reaction. Further, the necessary amount of source gases can be reliably supplied in order to from ruthenium cyclopentane films.

[0113] Further, ruthenium ethyl cyclopentane (Ru(EtCP)2) which is liquid at the normal pressures and temperatures can be used for forming ruthenium films. In this case, the semiconductor manufacturing device **1** or the semiconductor manufacturing system of **FIG. 11** is also usable.

[0114] (Second Embodiment of the Invention)

[0115] In this embodiment, the buffer unit **4** of the first embodiment is provided as an external semiconductor manufacturing device.

[0116] Referring to **FIG. 13**, the external semiconductor manufacturing device **1A** is provided as an external device in addition to the semiconductor manufacturing device **1** with the substrate treating chamber **2**, and includes the buffer unit **4** in order to receive and store the substrate treating substance from the external source **20**, and delivers the stored substrate treating substance to the substrate treating chamber **2** of the semiconductor manufacturing device **1**.

[0117] The external semiconductor manufacturing device **1A** includes: a control unit **6A** controlling the substrate treating substance in the buffer unit **4**; the measuring unit **5** measuring the substrate treating substance; the pneumatic valve **702** controlling the delivery of the mono-silane gas from the mono-silane gas cylinder **21** of the external source **20**; the pneumatic valve **703** controlling the delivery of the nitride gas from the nitride gas generator **22**; the pneumatic valve **701** controlling the delivery of the fluorine gas from the fluorine gas generator **23**; and the pneumatic valve **801** controlling the delivery of the substrate treating substance to the substrate treating chamber **2** of the semiconductor manufacturing device **1** from the buffer unit **4**. The control unit **6A** is dedicated to the buffer unit **4**, controls the pneumatic valves **701** to **703** and **801**, and is controlled by the CIM system via the LAN **13**.

[0118] In this embodiment, the semiconductor manufacturing device **1** is essentially identical to the semiconductor manufacturing device **1** of the first embodiment except for the buffer unit **4**, measuring unit **5**, pneumatic valves **701** to **703** and **801**, all of which constitute the external semiconductor manufacturing device **1A**. The external semiconductor manufacturing device **1A** includes the control unit **6A** dedicated to the buffer unit **4** in order to control the temperatures of the heater **202** and the operation of the gate valve **802**.

[0119] The external semiconductor manufacturing device **1A** including the buffer unit **4** functions as an external unit for the semiconductor manufacturing device **1** which actually deposits films. The combination of the semiconductor manufacturing devices **1** and **1A** is as effective as the semiconductor manufacturing device **1** or the semiconductor manufacturing system of the first embodiment. Further, the external semiconductor manufacturing device **1A** is very versatile, and can be attached to a different semiconductor manufacturing device, e.g. a sputtering device, an etching device, a cleaning device or the like.

[0120] (Third Embodiment of the Invention)

[0121] In this embodiment, the semiconductor manufacturing device **1** or the semiconductor manufacturing system of the first embodiment is applied to cleaning an inner wall of a reaction tube **201** of the substrate treating chamber **2**.

[0122] [Basic Cleaning Method]

[0123] The following describe, with reference to **FIG. 1**, how to clean the inner wall of the reaction tube **201** covered with polycrystalline silicon films deposited by the LPCVD process. The foregoing process directly relates to the making of the polycrystalline silicon films. However, the cleaning process is indirect but indispensable to make the polycrystalline silicon films.

[0124] (1) First of all, cleaning data are transmitted to the control unit **6** of the semiconductor manufacturing device **1** from the manufacture managing database **11** via the LAN **13** as shown in **FIG. 1**. The cleaning data denote at least etching data and so on which are necessary to remove the polycrystalline silicon films from the inner wall of the substrate treating chamber **2**. For instance, in order to remove a 100 nm-thick polycrystalline silicon film from the inner wall of the reaction tube **201**, etching should be performed by introducing for 5 minutes a fluorine gas at the feed rate of 1000 sccm, at the temperature of 300° C. and at the pressure of 1.333×10^3 Pa. A total of 5000 scc fluorine gas will be introduced in 5 minutes.

[0125] (2) In this embodiment, the buffer unit **4** has a capacity of 5000 scc in order to clean the substrate treating chamber **2**. In response to the cleaning data, the control unit **6** opens the pneumatic valve **801**, thereby evacuating the buffer unit **4** to a sufficiently low pressure by the vacuum exhaust pump **30**.

[0126] (3) Thereafter, the control unit **6** closes the pneumatic valve **801**, and opens the pneumatic valve **701**, so that the fluorine gas will be introduced into the buffer unit **4** from the fluorine gas generator **23** of the external source **20**.

[0127] (4) The 5000 scc fluorine gas (corresponding to 5000 cm^3 of the fluorine gas in the normal state) is filled in the buffer unit **4**, and is stored therein as soon as the control unit **6** closes the pneumatic valve **701**. The fluorine gas generator **23** generates the fluorine gas by the electrolysis of KF and 2HF, or pyrolysis of KF and 6HF. When the fluorine gas is generated at the rate of 100 sscm/min, the fluorine gas generator **23** should have a capacity which is ten times as large as its normal capacity in order to generate the fluorine gas at the feed rate of 1000 sccm. However, such a feed rate is necessary for only approximately 5 minutes for the cleaning process.

[0128] In this embodiment, the buffer unit **4** starts to store the fluorine gas 50 minutes prior to the cleaning process, so that the necessary 1000 sccm fluorine gas can be obtained even when the fluorine gas generator **23** has only the 100 sccm capacity.

[0129] In other words, the buffer unit **4** starts storing the fluorine gas immediately after the polycrystalline silicon film is formed and the mono silane gas is emitted therefrom. Further, the fluorine gas is stored during the cleaning of the reaction tube **201**, during the return of the pressure in the buffer unit **4** to the normal state, during the unloading of the semiconductor wafer from the substrate treating chamber **2**, and during the evacuation and thermal stabilization of the buffer unit **4** for the cleaning process. Therefore, the cleaning period is not lengthened.

[**0130**] Alternatively, the buffer unit **4** is dedicated to the storage of the mono-silane gas, and a cleaning buffer unit **4** may be provided in order to store the fluorine gas. The cleaning buffer unit **4** may be incorporated in the semiconductor manufacturing device **1** as in the first embodiment, or may be provided as an external unit similarly to the external semiconductor manufacturing device **1A** of the second embodiment.

[**0131**] (5) The fluorine gas is delivered to the substrate treating chamber **2** from the buffer unit **4** in order to clear the substrate treating chamber **2**.

[**0132**] Generally speaking, the substrate treating chamber **2** is cleaned less frequently than the number of times of polycrystalline silicon film deposition, which is effective in reducing the supply capacity of the fluorine gas generator **23**. In other words, capacities of the external source **20** and gas delivery facilities can be reduced, and capital investment for such an external source and gas delivery facilities can be also reduced.

[**0133**] In the third embodiment, the cleaning process (etching process) for the substrate treating chamber **2** is essentially identical to the polycrystalline silicon film deposition in the first embodiment. Especially, in the cleaning process, a final point of temperature rise, analysis of exhaust gases and so on in the reaction tube **20** can be monitored on the real time basis. Therefore, the semiconductor manufacturing system shown in **FIG. 7** is very effective since it controls the cleaning process on the basis of a total amount of supplied fluorine gas without controlling the feed rate of the fluorine gas using the mass flow controller **811**, conductance regulator **812** and so on. In the semiconductor manufacturing system of **FIG. 7**, it is not necessary to measure time-dependent variations of the etching rate beforehand.

FIRST MODIFIED EXAMPLE

[**0134**] In a first modified example of the third embodiment, the semiconductor manufacturing device **1** or the semiconductor manufacturing system includes a retrieving buffer unit **35** (a second buffer unit) between the substrate treating chamber **2** and the vacuum exhaust pump **30** in parallel. Referring to **FIG. 14**, the retrieving buffer unit **35** connects to the external source **20** via a three-way valve **805**, to the vacuum exhaust pump **30** via a valve **806**, and to the buffer unit **4** via a return valve **807**.

[**0135**] The retrieving buffer unit **35** retrieves and stores the cleaning gas (fluorine gas) exhausted from the substrate treating chamber **2**, and delivers it to the buffer unit **4**. The fluorine gas returned to the buffer unit **4** is reused for a next following cleaning of the substrate treating chamber **2**, which is effective in promoting to effective use of the cleaning gas, reducing cleaning cost, and promoting energy saving. The retrieving buffer unit **35** may be positioned in either in or out of the semiconductor manufacturing device **1**.

SECOND MODIFIED EXAMPLE

[**0136**] Referring to **FIG. 15**, the semiconductor manufacturing system includes a temporary storage buffer unit **36** between the vacuum exhaust pump **30** and the purifier **31**. The temporary storage buffer unit **36** temporarily stores an exhaust gas, and is connected to the vacuum exhaust pump **30** via a three-way valve **808** and an exhaust gas compressor **37**, to the nitride gas generator **22** via a valve **810** in order to supply a nitride gas, and to the purifier **31** via a return valve **809**.

[**0137**] In this modified example, the semiconductor manufacturing device **1** handles not only the substrate treating substances such as source gases used for the film deposition and cleaning gases used for the cleaning of the substrate treating chamber **2**, and it also handles the exhaust gas. Specifically, the temporary storage buffer unit **36** is provided in a path for discharging exhaust gases, and functions similarly to the buffer unit **4**. If exhaust gases are discharged beyond the capacity of the purifier **31**, the temporary storage buffer unit **36** controls a feed rate of the exhaust gases. Generally, the purifier **31** operates only while the exhaust gases are being discharged. The temporary storage buffer unit **36** enables the purifier **31** to process exhaust gases from a plurality of semiconductor manufacturing devices **1** (not shown).

[**0138**] In the foregoing case, the temporary storage buffer unit **36** temporarily stores exhaust gases, and gradually supplies them to the purifier **31**, so that the purifier **31** can reliably process them. Even if one semiconductor manufacturing device **1** happens to discharge exhaust gases beyond the capacity of the purifier **31**, the temporary storage buffer unit **35** operates as described above.

[**0139**] Therefore, the purifier **31** can have a reduced capacity. Further, a setting number of purifiers **31** can be reduced in the semiconductor manufacturing system. The gas source and delivery facilities of the semiconductor manufacturing system can be downsized, and capital investment for such facilities can be reduced.

[**0140**] (Fourth Embodiment of the Invention)

[**0141**] In this embodiment, the present invention is applied to the cleaning of inner walls of reaction tubes in the substrate treating chambers of a plurality of semiconductor manufacturing devices in the semiconductor manufacturing system of the third embodiment.

[**0142**] [Basic Structure of Semiconductor Manufacturing Device and Semiconductor Manufacturing System]

[**0143**] Referring to **FIG. 16**, the semiconductor manufacturing system comprises at least: a plurality of semiconductor manufacturing devices **1(1)**, **1(2)** and **1(3)**; an external source **20** supplying substrate treating substances to the semiconductor manufacturing devices **1(1)** to **1(3)**; a external semiconductor manufacturing device **1B** distributing the substrate treating substances to the semiconductor manufacturing devices **1(1)** to **1(3)**; and a CIM server **14**.

[**0144**] The semiconductor manufacturing device **1(1)** is essentially identical to the semiconductor manufacturing device **1** of the first embodiment (refer to **FIG. 1**), and includes at least: a substrate treating chamber **2**; a buffer unit **4** receiving and storing the substrate treating substances from the external source **20** and delivering the substrate treating substances to the substrate treating chamber **2** or the semiconductor manufacturing device **1(1)**; a control unit **6(1)** controlling the states of the substrate treating substances in the buffer unit **4(1)**; and a measuring unit **5** (not shown) measuring the state of the substrate treating substances. The control unit **6(1)** is connected to the CIM server **14** via the LAN **13**.

[**0145**] The semiconductor manufacturing device **1(2)** is identical to the semiconductor manufacturing device **1(1)**, and includes at least: a substrate treating chamber **2** (not shown), a measuring unit **5**, a buffer unit **4(2)**, and a control unit **6(2)**. The semiconductor manufacturing device **1(3)** includes at least: a substrate treating chamber **2** (not shown), a measuring unit **5**, a buffer unit **4(3)**, and a control unit **6(3)**. The semiconductor manufacturing system is assumed to include three semiconductor manufacturing devices **1(1)** to **1(3)** in order to simplify the description thereof. Alternatively, the semiconductor manufacturing system may have two semiconductor manufacturing devices **1** or four or more semiconductor manufacturing devices **1**.

[**0146**] The external semiconductor manufacturing device 1B is essentially identical to the external semiconductor manufacturing device 1A of the second embodiment (shown in **FIG. 13**), but does not include a substrate treating chamber **2**, and functions only as a buffer. Specifically, the external semiconductor manufacturing device **1B** receives and stores the substrate treating substances from the external source **20**, and includes a buffer unit 4B delivering the substrate treating substances to an external unit, distribution valves **721**, **722** and **723**, and a control unit **6**B controlling the operations of the valves **721** to **723**.

[**0147**] In this embodiment, the substrate treating chambers **2** of the semiconductor manufacturing devices **1(1)** to **1(3)** are cleaned using fluorine gases temporarily stored in the buffer unit 4B, which is connected to a fluorine gas generator **23** of the external source **20**.

[**0148**] The distribution valve **721** is positioned between the buffer unit 4B and the semiconductor manufacturing device **1(1)**, and is controlled by the control unit **6**B. The distribution valve **722** is provided between the buffer unit **4**B and the semiconductor manufacturing device **1(2)**, and is controlled by the control unit **6**B. The distribution valve **723** is provided between the buffer unit **4**B and the semiconductor manufacturing device **1(3)**, and is controlled by the control unit **6**B. The control unit **6**B is connected to the CIM server **14** via the LAN **13**.

[**0149**] The CIM server **14** stores information concerning order of processing raw semiconductor wafer lots, information concerning kinds of lots, and classified information concerning priorities of processing sequences in manufacturing lines, and so on. The CIM server **14** manages manufacturing schedules on the basis of these pieces of information, i.e. which lot should be processed and when it should be processed by the semiconductor manufacturing device **1(1)**, **1(2)** or **1(3)**.

[**0150**] The CIM server **14** can calculate currently accumulated thicknesses of the polycrystalline silicon films obtained in each substrate treating chamber **2** of each of the semiconductor manufacturing devices **1(1)** to **1(3)**. Further, the CIM server **14** can artificially or automatically calculate and estimate a recommended film thickness for cleaning the substrate treating chambers **2** on the basis of chronological information, in present or past, on film thicknesses or film dust. Still further, the CIM server **14** can prepare schedules concerning a time to clean the substrate treating chambers **2** on the basis of the calculated and estimated data, information concerning current or waiting lots, manufacture schedules and so on.

[**0151**] [Operation of Semiconductor Manufacturing Device and Semiconductor Manufacturing System, and Substrate Treating Method]

[**0152**] The cleaning is performed as briefly described hereinafter.

[**0153**] (1) First of all, the CIM server **14** prepares a cleaning schedule for the semiconductor manufacturing device **1(1)**, **1(2)** or **1(3)** which should be cleaned. It is assumed here that the substrate treating chamber **2** of the semiconductor manufacturing device **1(1)** should be cleaned first.

[**0154**] (2) In accordance with the cleaning schedule, the CIM server **14** not only provides control information to the control unit **6(1)** of the semiconductor manufacturing device **1(1)** via the LAN **13** and opens the pneumatic valve **701**, but also provides the control information to the control units **6(2)** and **6(3)** of the semiconductor manufacturing devices **1(2)** and **1(3)**, and closes the pneumatic valves **701** of the semiconductor manufacturing devices **1(2)** and **1(3)**.

[**0155**] (3) The fluorine gas generator **23** supplies the fluorine gas to the buffer unit **4**B of the external semiconductor manufacturing device **1**B. The buffer unit **4**B stores the fluorine gas therein.

[**0156**] (4) The CIM server **14** opens the distribution valve **721** via the control unit **6**B of the external semiconductor manufacturing device **1**B, and closes the distribution valves **722** and **723**. The fluorine gas from the buffer unit **4**B is delivered to and stored in the buffer unit **4(1)** of the semiconductor manufacturing device **1(1)**. An amount of the fluorine gas in the buffer unit **4(1)** is equal to the amount necessary for the cleaning process which has been calculated by the CIM server **14** on the basis of the accumulated film thickness information. For instance, the amount of the stored fluorine gas can be easily measured and controlled using the pressure regulator **710** (shown in **FIG. 2**), the mass flow controller **711** (shown in **FIG. 3**) or the conductance regulator **712** (shown in **FIG. 4**). When the preset amount of the fluorine gas is stored in the buffer unit **4(1)**, this information is transmitted to the CIM server **14** via the LAN **13**.

[**0157**] (5) The CIM server **14** starts to supply the fluorine gas to the buffer units **4(2)** and **4(3)** of the semiconductor manufacturing device **1(2)** and **1(3)**, respectively, in accordance with the priority of the next following cleaning process. These buffer units **4(2)** and **4(3)** can store the fluorine gas necessary for the cleaning process.

[**0158**] (6) In the foregoing state, if the fluorine gas stored in the buffer units **4(1)** to **4(3)** is not in use, the fluorine gas supplied from the fluorine gas generator **23** is stored in the buffer unit 4B of the external semiconductor manufacturing device 1B to a pressure limit. Further, when the fluorine gas in the buffer units **4(1)** to **4(3)** is not still in use, the fluorine gas generator **23** is stopped in response to a control command from the CIM server **14**.

[**0159**] (7) The substrate treating chamber **2** of the semiconductor manufacturing device **1(1)** is cleaned using the fluorine gas in the buffer unit **4(1)**. Further, the substrate treating chambers **2** of the semiconductor manufacturing devices **1(2)** and **1(3)** are also cleaned using the fluorine gases in the buffer units **4(2)** and **4(3)**, respectively.

[**0160**] In the fourth embodiment, the external semiconductor manufacturing device **1B** including the buffer unit **4B** serves for the devices **4(1)** to **4(3)**, which enables effective use of the fluorine gas generator **23**. Therefore, it is possible to downsize the fluorine gas generator **23** and facilities for supplying the fluorine gas, and reduce installation cost, maintenance cost and so on.

[**0161**] Further, the external semiconductor manufacturing device **1B** with the buffer unit **4B** serves for semiconductor manufacturing devices without any buffer units in addition to the semiconductor manufacturing devices **4(1)** to **4(3)**. For instance, those semiconductor manufacturing devices can be designed in a manner such that any of their valves can operate together with the valve **721**, **722** or **723** of the external semiconductor manufacturing device **1B** in response to the control command from the CIM server **14**. In this case, those semiconductor manufacturing devices can function as if they include buffer units **4**.

[**0162**] The external semiconductor manufacturing device **1B** with the buffer unit **4B** is attached as an external unit to the external source **20** in the fourth embodiment. Alternatively, the external semiconductor manufacturing device **1B** may be incorporated in the external source **20**.

MODIFIED EXAMPLE

[**0163**] In a modified example of the fourth embodiment, a semiconductor manufacturing system comprises at least the semiconductor manufacturing devices **1(1)**, **1(2)** and **1(3)**, the external source **20** supplying the substrate treating substances to the semiconductor manufacturing devices **1(1)** to **1(3)**, a external semiconductor manufacturing device IC distributing the substrate treating substances from the external source **20** to the semiconductor manufacturing devices **1(1)** to **1(3)**, and the CIM server **14** managing the semiconductor manufacturing devices **1(1)** to **1(3)**. Refer to **FIG. 17**.

[**0164**] The semiconductor manufacturing device **1(1)** is essentially identical to the semiconductor manufacturing device **1** of the second embodiment (shown in **FIG. 13**), and includes at least a substrate treating chamber **2**, and a control unit **6(1)** controlling the substrate treating chamber **2**. The control unit **6(1)** is connected to the CIM server **14** via the LAN **13**. However, the semiconductor manufacturing device **1(1)** does not include any buffer unit **4(1)**, and differs from the semiconductor manufacturing device **1(1)** of the fourth embodiment in this respect.

[**0165**] The semiconductor manufacturing devices **1(2)** and **1(3)** include at least treating chambers **2** and control units **6(2)** and **6(3)**, respectively. The following describe the semiconductor manufacturing system having three semiconductor manufacturing devices **1(1)** to **1(3)**. Alternatively, the semiconductor manufacturing system may have two or more than four semiconductor manufacturing devices.

[**0166**] The external semiconductor manufacturing device IC is essentially identical to the external semiconductor manufacturing device **1B** of the fourth embodiment (shown in **FIG. 16**), but does not have any substrate treating chamber **2**, and functions as a dedicated buffer unit. The external semiconductor manufacturing device IC includes at least a main buffer unit **4C** and sub-buffer units **4C1** to **4C3**. The main buffer unit **4C** receives the substrate treating substance from the external source **20**, stores them and delivers them to the sub-buffer units **4C1** to **4C3**, which transfer them to the semiconductor manufacturing devices **1(1)** to **1(3)**.

[**0167**] The external semiconductor manufacturing device IC includes: valves **721** to **723** via which the substrate treating substance is distributed to the sub-buffer units **4C1** to **4C3** from the main buffer unit **4C**; pneumatic valves **725** to **727** via which the substrate treating substance is distributed to the semiconductor manufacturing devices **1(1)** to **1(3)**; and a control unit **6C** controlling the operations of the valves **721** to **723** and **725** to **727**, and is connected to the CIM server **14** via the LAN **13**.

[**0168**] The substrate treating substance, i.e. the fluorine gas, in the main buffer unit **4C** is used for cleaning the substrate treating chambers **2** of the semiconductor manufacturing devices **1(1)** to **1(3)**. Specifically, the fluorine gas from the fluorine gas generator **23** is temporarily stored in the main buffer unit **4C**, is distributed to the sub-buffer units **4C1** to **4C3**, and is temporarily stored therein. Thereafter, the fluorine gas is delivered to the semiconductor manufacturing devices **1(1)** to **1(3)** via the pneumatic valves **725** to **727**. In short, the external semiconductor manufacturing device IC includes the sub-buffer units **4C1** to **4C3** which serve for the semiconductor manufacturing devices **1(1)** to **1(3)**.

[**0169**] The semiconductor manufacturing system of the modified example is as effective and advantageous as the semiconductor manufacturing system of the fourth embodiment.

[**0170**] In the modified example, the external semiconductor manufacturing device IC is provided as an external unit for the external source **20**. Alternatively the external semiconductor manufacturing device **1C** may be incorporated in the external source **20**.

[**0171**] (Fifth Embodiment of the Invention)

[**0172**] In this embodiment, the present invention is applied to a semiconductor wafer cleaning device (semiconductor manufacturing device) and a semiconductor wafer cleaning system (semiconductor manufacturing system) in which a cleaning agent can be recycled.

[**0173**] [Basic Structure of Semiconductor Manufacturing Device and Semiconductor Manufacturing System]

[**0174**] Referring to **FIG. 18**, the semiconductor manufacturing system (semiconductor wafer cleaning system) comprises at least: semiconductor manufacturing devices **1(4)**, **1(5)** and **1(6)** cleaning substrates; a primary tube **90** introducing a cleaning agent; an evaporating/refining unit **95** which evaporates and refines the cleaning agent discharged from the semiconductor manufacturing devices **1(4)**, **1(5)** and **1(6)**; and external semiconductor manufacturing devices ID, 1E and 1F which are provided with buffer units **4D**, **4E** and **4F** receiving and storing the cleaning agent from the primary tube **90** or the evaporating/refining unit **95**, respectively.

[**0175**] Although not shown in detail, the semiconductor manufacturing device **1(4)** is structured to function as a single wafer cleaning device. In other words, the semiconductor manufacturing device **1(4)** is sheet-fed processing type cleaning device. The semiconductor manufacturing devices **1(5)** and **1(6)** whose structure is not shown in detail function as semiconductor wafer cleaning devices of the batch processing type.

[0176] A primary tube **90** is arranged in the clean room **100**, and simultaneously supplies the cleaning agent, i.e. a hydrogen fluoride solution (HF), to the semiconductor manufacturing devices **1(4)** to **1(6)** via control valves **731**, which are opened or closed by the database **11** of the CIM system via the LAN **13**.

[0177] The hydrogen fluoride solution used for cleaning semiconductor wafers is discharged from the semiconductor manufacturing devices **1(4)** to **1(6)** to the evaporating/refining unit **95** via a conduit pipe **91**. Specifically, a part of the hydrogen fluoride solution is used for cleaning semiconductor wafers (i.e. for etching silicon oxide films) while a part of the remaining hydrogen fluoride solution is diluted by pure water or like, and is discharged via the conduit pipe **91**. Only the hydrogen fluoride components of the discharged hydrogen fluoride solution are extracted and refined by the evaporating/refining unit **95**. The refined hydrogen fluoride solution is delivered to the external semiconductor manufacturing devices **1**D to **1**F via a return pipe **94**, and is reused. Non-reused hydrogen fluoride solution is discharged via an industry effluent pipe **93**.

[0178] The buffer unit **4**D of the external semiconductor manufacturing device **1**D stores the hydrogen fluoride solution (supplied via the primary valve **90** and the control valve **731**) and the recycled hydrogen fluoride solution (delivered from the evaporating/refining unit **95** via the return valve **94** and the control valve **732**), and delivers the stored hydrogen fluoride solutions to the semiconductor manufacturing device **1(4)**. The operation of the control valve **732** is controlled by the control unit **6**D connected to the CIM system via the LAN **13**.

[0179] Similarly to the external semiconductor manufacturing device ID, the buffer unit **4**E of the external semiconductor manufacturing device **1**E stores the hydrogen fluoride solution (supplied via the primary valve **90** and the control valve **731**) and the recycled hydrogen fluoride solution (delivered from the evaporating/refining unit **95** via the return valve **94** and the control valve **732**), and delivers the stored hydrogen fluoride solutions to the semiconductor manufacturing device **1(5)**. The operation of the control valve **732** is controlled by the control unit **6**E connected to the CIM system via the LAN **13**.

[0180] The buffer unit **4**F of the external semiconductor manufacturing device IF stores the hydrogen fluoride solution (supplied via the primary valve **90** and the control valve **731**) and the reused hydrogen fluoride solution (delivered from the evaporating/refining unit **95** via the return valve **94** and the control valve **732**), and delivers the stored hydrogen fluoride solutions to the semiconductor manufacturing device **1(6)**. The operation of the control valve **732** is controlled by the control unit **6**F.

[0181] [Operation of Semiconductor Manufacturing Device and Semiconductor Manufacturing System, and Substrate Treating Method]

[0182] The following describe the operations of the semiconductor manufacturing devices **1(4)** to **1(6)** (semiconductor wafer cleaning devices), external semiconductor manufacturing devices **1**D to **1**F having the buffer units **4**D, **4**E and **4**F, and semiconductor manufacturing system.

[0183] (1) In the semiconductor manufacturing devices **1(4)** to **1(6)**, the hydrogen fluoride solution is delivered to and stored in the buffer units **4**D, **4**E and **4**F via the primary supply pipe **90** and the control valve **731**. The hydrogen fluoride solution stored in the buffer units **4**D, **4**E and **4**F is used for cleaning semiconductor wafers in the semiconductor manufacturing devices **1(4)**, **1(5)** and **1(6)**, respectively.

[0184] (2) As in the fourth embodiment, the CIM server **14** (not shown) calculates amounts of the hydrogen fluoride solution to be distributed to the semiconductor manufacturing devices **1(4)** to **1(6)** (not shown) on the basis of distribution priority order. The operation of the control valves **731** and **732** is controlled via the LAN **13** on the basis of the calculated results. For instance, the hydrogen fluoride solution is preferentially delivered to the semiconductor manufacturing device **1(4)**.

[0185] (3) If necessary, an extensively pure hydrogen fluoride solution for cleaning semiconductor wafers is preferentially delivered to the semiconductor manufacturing device **1** via the primary supply pipe **90** and the buffer unit **4**. Otherwise, the recycled hydrogen fluoride solution is preferentially supplied from the evaporating/refining unit **95**.

[0186] (4) Usually, the recycled hydrogen fluoride solution is preferentially applied to cleaning semiconductor wafers. When the recycled hydrogen fluoride solution becomes short, the hydrogen fluoride solution is re supplied to the semiconductor manufacturing device **1** via the primary supply pipe **90** and the buffer unit **4**.

[0187] The semiconductor wafer cleaning system of this embodiment includes the buffer units **4**D to **4**F in order to store the hydrogen fluoride solution from the primary supply pipe **90** and the recycled hydrogen fluoride solution from the evaporating/refining unit **95**. The hydrogen fluoride solutions are stored in the buffer units **4**D to **4**F under control of the CIM system during the cleaning or delivery of semiconductor wafers. It is possible to carry out the cleaning process at the predetermined speed, and downsize the semiconductor manufacturing system or the cleaning agent delivering facilities. Generally, a semiconductor manufacturing system tends to become bulky when it includes the recycling unit as well as the evaporating/refining unit **95**. As a result, the cleaning agent delivery facilities also become bulky. The semiconductor manufacturing system of the fifth embodiment can be downsized because it is provided with the buffer units **4**D to **4**F.

[0188] Alternatively, the semiconductor manufacturing device and the semiconductor manufacturing system is also applicable to cleaning glass substrates, insulating substrates and so on. Further, the external semiconductor manufacturing devices **1**D to **1**F attached to the semiconductor manufacturing devices **1(4)** to **1(6)** as external units may be incorporated therein.

[0189] (Other Embodiments of the Invention)

[0190] The semiconductor manufacturing devices in the first and second embodiments are LPCVD devices. Alternatively, the present invention is applicable to CVD devices other than the LPCVD devices (e.g. an atmospheric CVD device or a plasma CVD device), or an epitaxial growth system. Further, the present invention is applicable not only to a system which includes different types of semiconductor manufacturing devices, film deposition devices, etching units, cleaning units and so on but also other substrate treating methods.

[0191] As described above, the present invention provides the semiconductor manufacturing device in which only necessary amounts of substances such as gases, liquids and solids directly or indirectly used for treating substrates are supplied only when they are necessary, and which can downsize the source and delivery pipes.

[0192] Further, the invention provides the semiconductor manufacturing system which can downsize substance sources and delivering facilities.

[0193] Finally, the invention provides the substrate treating method which promotes efficient use of the source and delivering facilities.

[0194] Although the present invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example only, and is not to be taken by way of limitation. The spirit and scope of the present invention are to be limited only by the terms of the appended claims.

What is claimed is:

1. A semiconductor manufacturing device comprising a buffer unit which receives a substrate treating substance from an external source, stores it therein, and delivers it to an external unit.

2. A semiconductor manufacturing device comprising:

a substrate treating chamber; and

a buffer unit provided in said substrate treating chamber or in said semiconductor manufacturing device, receiving a substrate treating substance from an external source, storing it therein, and delivering it to said substrate treating chamber or said semiconductor manufacturing device for the purpose of treating substrates.

3. The semiconductor manufacturing device of claim 1 or **2** further comprising a control unit controlling states of said substrate treating substance in said buffer unit.

4. The semiconductor manufacturing device of claim 1 or **2** further comprising a measuring unit measuring the states of said substrate treating substance in said buffer unit.

5. The semiconductor manufacturing device of claim 1 or **2**, wherein said buffer unit stores a predetermined amount of said substrate treating substance necessary for at least one substrate treating process in said substrate treating chamber or said semiconductor manufacturing device, and is capable of delivering said substrate treating substance to either said substrate treating chamber or said semiconductor manufacturing device.

6. The semiconductor manufacturing device of claim 1 or **2**, wherein said buffer unit stores simultaneously at least two kinds of substrate treating substances used by said substrate treating chamber, and is capable of delivering them to said substrate treating chamber.

7. The semiconductor manufacturing device of claim 1 or **2**, wherein said buffer unit reacts said substrate treating substance, and stores said reacted substrate treating substance therein.

8. The semiconductor manufacturing device of claim 3, wherein said control unit controls at least a temperature, a pressure or a concentration of said substrate treating substance stored in said buffer unit.

9. The semiconductor manufacturing device of claim 4, wherein said measuring unit measures at least a temperature, a pressure or a concentration of said substrate treating substance stored in said buffer unit.

10. The semiconductor manufacturing device of claim 1 or **2**, wherein said substrate treating substance in said substrate treating chamber or said manufacturing device is a gas, a liquid or a solid necessary for the substrate treatment.

11. The semiconductor manufacturing device of claim 1 or **2**, wherein said substrate treating substance is a cleaning gas for said substrate treating chamber.

12. The semiconductor manufacturing device of claim 1 or **2** further comprising a second buffer unit which recycles said substrate treating substance discharged from said substrate treating chamber or said semiconductor manufacturing device, and returns the recycled substrate treating substance to said substrate treating chamber or said semiconductor manufacturing device.

13. A semiconductor manufacturing system comprising:

an external source supplying a substrate treating substance;

a semiconductor manufacturing device including at least a substrate treating chamber;

a buffer unit receiving said a substrate treating substance from said external source, storing it therein, and delivering it to said substrate treating chamber or said semiconductor manufacturing device; and

a control unit controlling the delivery of said substrate treating substance from said external source to said buffer unit and the delivery of said substrate treating substance from said buffer unit to said substrate treating chamber or said semiconductor manufacturing device.

14. The semiconductor manufacturing system of claim 13 further comprising a computer-integrated manufacturing system which thoroughly manages the delivery of said substrate treating substance from said external unit, the receipt and storage of said substrate treating substance in and from said buffer unit, and controls the operations of said semiconductor manufacturing device and said control unit.

15. The semiconductor manufacturing system of claim 14, wherein said computer-integrated manufacturing system includes a record-keeping database which records and manages an in-service schedule of the substance treatment and a manufacture schedule, and controls at least a delivery speed or a delivery order of said substrate treating substance from said external source to said semiconductor manufacturing device via said buffer unit.

16. A substrate treating method comprising:

receiving a substrate treating substance from an external source, storing in a buffer unit said substrate treating substance necessary for at least one substrate treating process, and delivering a predetermined amount of said substrate treating substance to a substrate treating chamber or a semiconductor manufacturing device provided with a substrate treating chamber.

17. A substrate treating method comprising:

delivering substrates into a substrate treating chamber;

receiving a substrate treating substance from an external source, storing in a buffer unit said substrate treating substance necessary for at least one substrate treating process; and

delivering a predetermined amount of said substrate treating substance to a substrate treating chamber or a semiconductor manufacturing device provided with a substrate treating chamber.

18. The substrate treating method of claim 16 or **17**, wherein at least two kinds of substrate treating substances are simultaneously stored in said buffer unit.

19. The substrate treating method of claim 16 or **17**, wherein said substrate treating substance is reacted and is stored in said buffer unit.

20. The substrate treating method of claim 16 or **17**, wherein at least a temperature, a pressure or a concentration of said substrate treating substance stored in said buffer unit is controlled or measured.

21. The substrate treating method of claim 16 or **17**, wherein said substrate treating substances stored in said buffer unit are gases, liquids or solids.

22. The substrate treating method of claim 16 or **17**, wherein said substrate treating substances stored in said buffer unit are cleaning gases for said substrate treating chamber.

23. The substrate treating method of claim 16 or **17** further comprising:

recycling said substrate treating substance discharged from said substrate treating chamber or said semiconductor manufacturing device;

storing said recycled substrate treating substance in a second buffer unit; and

returning said recycled substrate treating substance to said substrate treating chamber or said semiconductor manufacturing device from said second buffer unit.

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