



(51) International Patent Classification:

H01L 21/67 (2006.01) C23C 16/52 (2006.01)

C23C 16/448 (2006.01) H01J 37/32 (2006.01)

(21) International Application Number:

PCT/US2024/033192

(22) International Filing Date:

10 June 2024 (10.06.2024)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

63/472,721 13 June 2023 (13.06.2023) US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available):

AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available):

ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ,

(54) Title: MULTIPLE FLOW-OVER-VAPOR AMPULE DELIVERY SYSTEMS

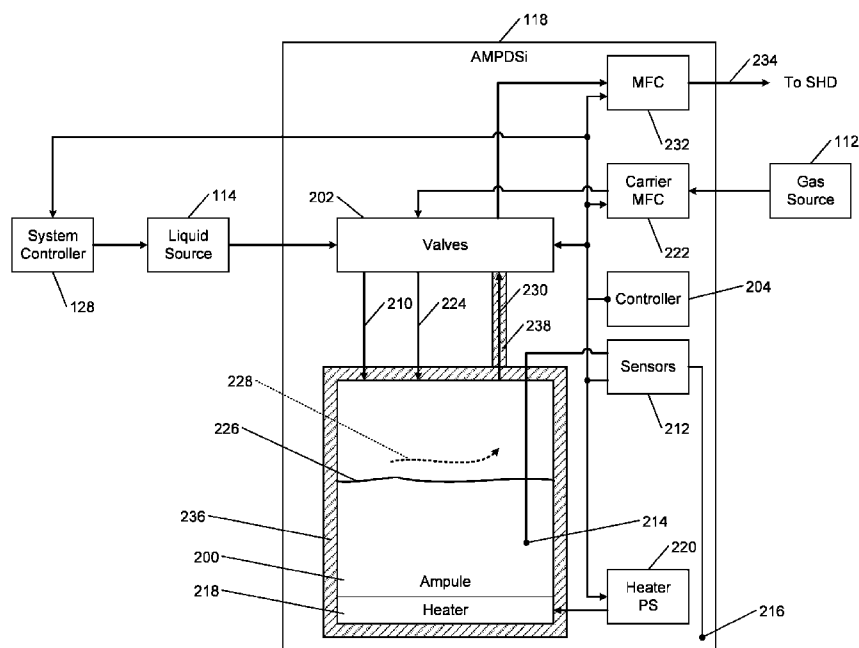


FIG. 2

(57) Abstract: An assembly for supplying vaporized precursors to a process module of a substrate processing system includes a plurality of delivery systems disposed in an enclosure and a thermal isolator disposed in the enclosure between adjacent ones of the delivery systems to thermally isolate the adjacent ones of the delivery systems from each other. Each delivery system includes a container, a heater and a conduit. The container includes a liquid precursor. The heater is configured to heat the liquid precursor in the container. The conduit is configured to supply a vaporized precursor generated in the container to the process module.

DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT,
LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE,
SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,
GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

MULTIPLE FLOW-OVER-VAPOR AMPULE DELIVERY SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 63/472,721 filed on June 13, 2023. The entire disclosure of the above application is
5 incorporated herein by reference.

FIELD

[0002] The present disclosure relates generally to substrate processing systems and more particularly to a multiple flow-over-vapor (FOV) ampule delivery systems (AMPDSs).

BACKGROUND

[0003] The background description provided here is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor
15 impliedly admitted as prior art against the present disclosure.

[0004] Substrate processing systems are used to treat substrates such as semiconductor wafers. A substrate processing system (also called a tool) comprises a processing chamber. The processing chamber comprises a plurality of process modules (also called stations). Each station can process a substrate. For example, the
20 processing may include deposition, etching, cleaning, and/or other substrate treatments. During processing, the substrate is arranged on a substrate support in the station. A gas delivery system introduces one or more gases and vaporized precursors into the station via a gas delivery device. For example, the gas delivery device can be a showerhead, an injector, and so on. In some processes, plasma may be used to initiate
25 chemical reactions.

SUMMARY

[0005] An assembly for supplying vaporized precursors to a process module of a substrate processing system comprises a plurality of delivery systems disposed in an enclosure and a thermal isolator disposed in the enclosure between adjacent ones of
30 the delivery systems to thermally isolate the adjacent ones of the delivery systems from

each other. Each delivery system comprises a container, a heater and a conduit. The container comprises a liquid precursor. The heater is configured to heat the liquid precursor in the container. The conduit is configured to supply a vaporized precursor generated in the container to the process module.

5 **[0006]** In additional features, the liquid precursors of the delivery systems are different from each other.

[0007] In additional features, the heaters of the delivery systems are configured to heat the liquid precursors to different temperatures.

10 **[0008]** In additional features, the delivery systems are configured to output the vaporized precursors from the respective conduits at different flow rates.

[0009] In additional features, the delivery systems are configured to output the vaporized precursors from the respective conduits at different temperatures and different flow rates.

15 **[0010]** In additional features, the liquid precursors of the delivery systems are different from each other. The delivery systems are configured to output the vaporized precursors from the respective conduits at different temperatures and different flow rates.

20 **[0011]** In additional features, each delivery system further comprises a controller configured to control a temperature and a flow rate of the vaporized precursor output from the conduit.

[0012] In additional features, the heaters of the delivery systems are configured to heat the liquid precursors of the delivery systems to different temperatures.

25 **[0013]** In additional features, each delivery system further comprises a power supply and a controller. The power supply is configured to supply power to the heater. The controller is configured to control the power supplied by the power supply to the heater to heat the liquid precursor to a predetermined temperature.

[0014] In additional features, the assembly further comprises a plurality of mass flow controllers configured to supply a gas to the delivery systems at predetermined flow rates, respectively.

[0015] In additional features, at least one of the delivery systems further comprises a mass flow controller configured to control a flow rate of the vaporized precursor output from the conduit.

5 **[0016]** In additional features, at least one of the delivery systems further comprises a pressure sensor and a controller. The pressure sensor is configured to sense a pressure of the vaporized precursor exiting the container. The controller is configured to control a flow rate of the vaporized precursor output from the conduit based on the sensed pressure.

10 **[0017]** In additional features, each delivery system further comprises a valve and a mass flow controller, a second heater, and a second thermal isolator. The valve and the mass flow controller are coupled to the conduit. The second heater is coupled to the valve, the mass flow controller, and the conduit. The second thermal isolator is disposed between a surface of the enclosure and the second heater, the valve, the mass flow controller, and the conduit to thermally isolate the second heater, the valve,
15 the mass flow controller, and the conduit from the surface of the enclosure.

[0018] In additional features, each delivery system further comprises a power supply and a controller. The power supply is configured to supply power to the heater. The controller is configured to control the power supplied to the heater to maintain a temperature of the vaporized precursor in the valve, the mass flow controller, and the
20 conduit.

[0019] In additional features, each delivery system further comprises a valve, a second heater, and a second thermal isolator. The valve is coupled to the conduit. The second heater is coupled to the valve and the conduit. The second thermal isolator is disposed between a surface of the enclosure and the second heater, the valve, and the
25 conduit to thermally isolate the second heater, the valve, and the conduit from the surface of the enclosure.

[0020] In additional features, each delivery system further comprises a power supply and a controller. The power supply is configured to supply power to the heater. The controller is configured to control the power supplied to the heater to maintain a
30 temperature of the vaporized precursor in the valve and the conduit.

[0021] In additional features, each delivery system further comprises a second conduit, and a heat shield. The second conduit is configured to supply the vaporized

precursor from the container to a valve. The conduit is coupled to the valve. The heat shield is disposed around the heater, the container, and the second conduit.

[0022] In additional features, the assembly further comprises a cover, a plurality of louvers, and an exhaust port. The cover is disposed on a first side of the assembly. The
5 louvers are provided on the cover. The exhaust port is provided on the assembly.

[0023] In additional features, each delivery system further comprises a power supply and a controller. The power supply is configured to supply power to the heater. The controller is configured to control the power supplied by the power supply to the heater to heat the liquid precursor to a predetermined temperature. The assembly further
10 comprises a plurality of mass flow controllers configured to supply a gas to the plurality of delivery systems, respectively. The power supplies, the controllers, and the mass flow controllers are disposed outside the assembly and are disposed on a second side of the assembly that is opposite to the first side of the assembly.

[0024] In additional features, each delivery system further comprises a controller
15 configured to control a temperature and a flow rate of the vaporized precursor output from the conduit. The controllers are configured to control a sequence in which the vaporized precursors are output from the delivery systems.

[0025] In additional features, the controllers are configured to control the delivery systems to output the vaporized precursors from the respective conduits in the
20 sequence at different flow rates.

[0026] In additional features, the controllers are configured to control the delivery systems to output the vaporized precursors from the respective conduits in the sequence at different temperatures and different flow rates.

[0027] In additional features, the liquid precursors of the delivery systems are different
25 from each other. The controllers are configured to control the delivery systems to output the vaporized precursors from the respective conduits in the sequence at different temperatures and different flow rates.

[0028] In additional features, each delivery system further comprises a controller configured to control a temperature and a flow rate of the vaporized precursor output
30 from the conduit. The controllers are configured to control at least two of the delivery systems to concurrently output the respective vaporized precursors from the respective conduits.

[0029] In additional features, the controllers are configured to control the at least two of the delivery systems to concurrently output the vaporized precursors from the respective conduits at different flow rates.

5 [0030] In additional features, the controllers are configured to control the at least two of the delivery systems to concurrently output the vaporized precursors from the respective conduits at different temperatures and different flow rates.

[0031] In additional features, the liquid precursors of the delivery systems are different from each other. The controllers are configured to control the at least two of the delivery systems to concurrently output the vaporized precursors from the respective conduits at
10 different temperatures and different flow rates.

[0032] Further areas of applicability of the present disclosure will become apparent from the detailed description, the claims and the drawings. The detailed description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the disclosure.

15 BRIEF DESCRIPTION OF THE DRAWINGS

[0033] The present disclosure will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0034] FIG. 1 shows an example of a substrate processing system comprising multiple ampule delivery systems (AMPDSs) of the present disclosure;

20 [0035] FIG. 2 shows an example of one of the AMPDSs;

[0036] FIG. 3A, 3B, and 3C shows examples of different configurations of one of the AMPDSs;

[0037] FIGS 4A and 4B show examples of heating and thermally isolating some of the components that are used to supply a vaporized precursor from one of the AMPDSs;

25 [0038] FIG. 5 shows a front view of an enclosure that encloses the AMPDSs;

[0039] FIG. 6A shows a front cover for the enclosure;

[0040] FIG. 6B shows a back view of the enclosure with some of the components of the AMPDSs mounted on a back panel of the enclosure; and

[0041] FIG. 7 shows a method for operating the AMPDSs.

[0042] In the drawings, reference numbers may be reused to identify similar and/or identical elements.

DETAILED DESCRIPTION

[0043] To deliver a vaporized precursor into the station during substrate processing, a flow-over-vapor (FOV) advanced modular precursor delivery system (AMPDS) may be used. The AMPDS comprises a FOV ampoule (hereinafter the ampoule). As used herein, the FOV ampoule (or ampoule) is a vapor delivery device comprising a container storing a liquid precursor, an inlet to receive a carrier gas to entrain a vaporized precursor generated by heating the liquid precursor, and an outlet to output the vaporized precursor. Accordingly, the ampoule stores a liquid precursor. The liquid precursor is heated to generate a vaporized precursor. A carrier gas is supplied to the ampoule. The carrier gas passes through the ampoule. The vaporized precursor is entrained by the carrier gas and delivered to the station. The ampoule comprises a level sensor to sense a level of the liquid precursor in the ampoule. A controller supplies the liquid precursor to the ampoule to maintain the level of the liquid precursor in the ampoule. Other sensors such as pressure sensors and/or mass flow controllers (MFCs) may be used to control the flow rates of the carrier gas and the vaporized precursor.

[0044] Some processes may require more than one vaporized precursor (e.g., a plurality of vaporized precursors) to process a substrate in a station. Further, the plurality of vaporized precursors may need to be delivered to the station at independently controlled temperatures and flow rates. The present disclosure provides multiple ampoule delivery systems to supply a plurality of vaporized precursors to a station at independently controlled temperatures and flow rates.

[0045] In general, a tool may already comprise a single AMPDS per station to supply a single vaporized precursor to a respective station in the tool. The present disclosure provides an assembly comprising multiple AMPDSs that can supply multiple vaporized precursors to one station. One such assembly can be used per station. The assembly can be used instead of or in addition to the single AMPDS. A plurality of vaporized precursors can be supplied to one station using a combination of the single AMPDS and the multiple AMPDSs in the assembly.

[0046] The plurality of vaporized precursors are supplied to the station through a multi-plenum showerhead. For example, the multi-plenum showerhead may comprise a dual-plenum showerhead or a triple-plenum showerhead. The multiple plenums in the showerhead are disjoint (i.e., are not in fluid communication with each other).

5 Accordingly, the vaporized precursors do not mix in the showerhead. The vaporized precursors can mix only in the station. In some processes, the vaporized precursors may be supplied individually or concurrently. In some processes, the vaporized precursors may be supplied in a sequence or in a combination. Plasma may be generated in the station when the vaporized precursors are introduced into the station.

10 **[0047]** Since each vaporized precursor may be supplied at a different temperature, the multiple AMPDSs in the assembly may be thermally isolated from each other. Further, heat shields may be used to thermally isolate the ampules and conduits in each AMPDS in the assembly. Furthermore, valves and MFCs used to supply the vaporized precursors from the multiple AMPDSs to the showerhead may be heated and thermally
15 isolated from the assembly. These and other features of the present disclosure are described below in detail.

[0048] The present disclosure is organized as follows. In a first section, an example of a substrate processing system comprising the multiple AMPDSs of the present disclosure is shown and described with reference to FIG. 1. In a second section, an
20 example of one of the multiple AMPDSs is shown and described with reference to FIG. 2. In a third section, examples of different configurations of one of the multiple AMPDSs are shown and described with reference to FIGS. 3A-3C. In a fourth section, examples of heating and thermally isolating valves and MFCs used to supply the vaporized precursor from one of the AMPDSs are shown and described with reference to FIGS.
25 4A and 4B. In a fifth section, different views of an assembly comprising the multiple AMPDSs and arrangements of different components inside and outside the assembly are shown and described with reference to FIGS. 5-6B. In a sixth section, a method for operating the AMPDSs is shown and described with reference to FIG. 7.

SECTION 1: EXAMPLE OF SUBSTRATE PROCESSING SYSTEM

30 **[0049]** FIG. 1 shows an example of a substrate processing system 100 comprising the multiple AMPDSs of the present disclosure. The substrate processing system (hereinafter the system) 100 comprises a station 102. While only one station 102 is

shown for example, the system 100 may comprise multiple stations. For each station, separate AMPDS0 and AMPDS1-3 (described below) are used.

[0050] The station 102 comprises a pedestal 104 and a showerhead 106. A substrate 108 is arranged on the pedestal 104 during processing. For example, the pedestal 104 may use vacuum clamping, electrostatic clamping, or some other clamping mechanism to clamp the substrate 108 to the pedestal 104. The pedestal 104 may be moved relative to the showerhead 106 by an actuator (e.g., a motor) 110 to adjust a gap between the showerhead 106 and the substrate 108. The showerhead 106 may be a dual-plenum showerhead or a triple-plenum showerhead. The pedestal 104 and the showerhead 106 may comprise a heater, a cooling channel, and a temperature sensor (all not shown).

[0051] The system 100 comprises a plurality of gas sources 112 and a plurality of liquid sources 114. The gas sources 112 supply a plurality of gases. For example, the gases comprise process gases, inert gases, purge gases, cleaning gases, etc. The liquid sources 114 supply a plurality of liquid precursors.

[0052] The system 100 comprises an AMPDS0 (shown at 116) that supplies a single vaporized precursor. The system 100 comprises an assembly comprising multiple AMPDSs (e.g., AMPDS1-3 shown at 118). The assembly and the AMPDSs are shown and described below in detail with reference to subsequent figures. Briefly, the liquid sources 114 supply liquid precursors to the AMPDS0 and the AMPDS1-3. The gas sources 112 supply carrier gases to the AMPDS0 and the AMPDS1-3. The AMPDS0 and the AMPDS1-3 generate and supply vaporized precursors to the showerhead 106 through a manifold 116.

[0053] The AMPDS0 and the AMPDS1-3 supply the vaporized precursors to separate (disjoint) plenums in the showerhead 106. The AMPDS0 and the AMPDS1-3 supply the vaporized precursors at respective temperatures and flow rates. The temperatures and flow rates of the vaporized precursors are independently controlled as described below in detail. The vaporized precursors do not mix in the manifold 116 and in the showerhead 106. The vaporized precursors mix in the station 102.

[0054] The system 100 comprises a radio frequency (RF) power supply 120. The RF power supply 120 supplies RF power to the showerhead 106 with the pedestal 104 grounded. Alternatively, the power supply 120 may supply RF power to the pedestal 104 with the showerhead 106 grounded. The RF power supply 120 supplies the RF

power to strike plasma 122 when the vaporized precursors are introduced into the station 102 through the showerhead 106.

[0055] The system 100 comprises a valve 124 and a pump 126. The pump 126 is connected to the station 102 via the valve 124. The pump 126 maintains pressure (e.g., vacuum) in the station 102 during the processing of the substrate 108. The pump 126 is connected to an exhaust system (not shown). The pump 126 evacuates reactants and reaction byproducts from the station 102 into the exhaust system. The system 100 comprises a system controller 128 that controls all the components of the system 100 described above.

10 SECTION 2: EXAMPLE OF AMPDS

[0056] FIG. 2 shows an example of one of the multiple AMPDSs. In the example shown, the AMPDS is called AMPDS_i, where $i = 1, 2, \text{ or } 3$, for example. In some examples, i can be any positive integer. Thus, AMPDS_i represents each AMPDS in AMPDS1-3 shown at 118 in FIG. 1. Hereinafter, the AMPDS_i is called the AMPDS 118.

15 The following description of the AMPDS 118 applies equally to each AMPDS in AMPDS1-3 shown at 118 in FIG. 1. Further, the AMPDS0 shown at 116 in FIG. 1 may also be similar to the AMPDS 118. Therefore, the following description of the AMPDS 118 may also apply equally to the AMPDS0 except that the AMPDS0 is a single AMPDS that supplies a single vaporized precursor.

20 **[0057]** The AMPDS 118 comprises an ampule 200, a plurality of valves 202, and a controller 204. The valves 202 can also be called a valve block. The valve block comprises a manifold 206 (shown in FIGS. 4A and 4B). The valves 202 are connected to the manifold 206. The controller 204 controls the valves 202 to route various fluids (gas, liquid, and vapor) in and out of the AMPDS 118 as described below. The controller 204 of the AMPDS 118 communicates with the system controller 128 of the system 100. The controller 204 controls various components of the AMPDS 118 as described below.

[0058] The liquid source 114 supplies a liquid precursor to the ampule 200 via one of the valves 202. The liquid precursor flows into the ampule 200 through a conduit 210.

30 The conduit 210 is connected between the ampule 200 and the valve block. The AMPDS 118 comprises a plurality of sensors 212. The sensors 212 communicate with the controller 204 of the AMPDS 118. For example, the sensors 212 comprise a level sensor 214 that senses a level of the liquid precursor in the ampule 200. Based on the

level of the liquid precursor in the ampule 200 detected by the level sensor 214, the controller 204 and the system controller 128 control the liquid source 114 to maintain the level of the liquid precursor in the ampule 200.

[0059] The sensors 212 also comprise a leak detection sensor 216 to detect any leaked liquid precursor in the AMPDS 118. When a leakage is detected, the controller 204 and the system controller 128 can generate an alert (e.g., an alarm) for an operator of the system 100 to intervene. Alternatively, the controller 204 and the system controller 128 can suspend operation of the AMPDS 118 or of the station 102.

[0060] The AMPDS 118 comprises a heater 218 and a power supply (shown as heater PS) 220. The controller 204 controls the power supply 220. The power supply 220 supplies power to the heater 218. The heater 218 heats the liquid precursor in the ampule 200 to generate a vaporized precursor. The controller 204 controls the power supply 220 such that the heater 218 heats the liquid precursor to a predetermined temperature. Accordingly, the AMPDS 118 supplies the vaporized precursor at the predetermined temperature to the showerhead 106 of the station 102 via some of the valves 202 and a conduit 234, which are also heated as described below.

[0061] The AMPDS 118 comprises an MFC (shown as carrier MFC) 222. The MFC 222 receives a carrier gas from the gas source 112. For examples, the carrier gas comprises an inert gas. The controller 204 controls the MFC 222. The MFC 222 supplies the carrier gas at a predetermined flow rate to the ampule 200 via one of the valves 202. The carrier gas flows into the ampule 200 through a conduit 224. The conduit 224 is connected between the ampule 200 and the valve block. The carrier gas entrains the vaporized precursor. The liquid precursor is shown at 226, and the vaporized precursor is shown at 228. The vaporized precursor flows out of the ampule 200 into a conduit 230. The conduit 230 is connected between the ampule 200 and the valve block.

[0062] The AMPDS 118 comprises an MFC 232. The controller 204 controls the MFC 232. The MFC 232 controls the flow rate at which the vaporized precursor is supplied through the conduit 234 to the showerhead 106 of the station 102 (shown in FIG. 1). For example, the conduit 234 may be connected to the showerhead 106 via the manifold 116 (shown in FIG. 1). The vaporized precursor from AMPDS 118 is supplied to one of the plenums of the showerhead 106 at a predetermined flow rate.

[0063] Additionally, the ampule 200 and the conduit 230 are surrounded by heat shields 236, 238, respectively. The heat shields 236, 238 prevent heat loss from the ampule 200 and the conduit 230 to the enclosure of the assembly (enclosure shown in FIGS. 5-6B) housing the AMPDS 118. The heat shields 236, 238 also maintain the temperature of the liquid precursor and the vaporized precursor in the AMPDS 118.

[0064] As shown and described below with reference to FIGS. 4A and 4B, the AMPDS 118 further comprises additional heaters. The additional heaters heat only some of the valves 202, the MFC 232, the conduit 234, and subsequent valves (shown in FIGS. 4A and 4B) that supply the vaporized precursor from the AMPDS 118 to the showerhead 106. The power supply 220 also supplies power to the additional heaters. The controller 204 also controls the additional heaters.

[0065] Further, the AMPDS 118 also comprises a thermal isolator (shown in FIGS. 4A and 4B). The thermal isolator thermally isolates the heated valves 202, the MFC 232, the conduit 234, and the subsequent valves from the enclosure of the assembly (shown in FIGS. 5-6B) housing the AMPDS 118. The additional heaters and the thermal isolator maintain the temperature of the vaporized precursor output from the AMPDS 118. Thus, the AMPDS 118 supplies the vaporized precursor at the predetermined temperature and the predetermined flow rate to the showerhead 106.

[0066] Each AMPDS of the AMPDS1-3 may supply a respective vaporized precursor to a respective plenum of the showerhead 106. In each AMPDS 118, the controller 204 controls the MFCs 222 and 232, the power supply 220, the heater 218, and the additional heaters. The system controller 128 communicates with the controllers 204 of the AMPDS1-3 and coordinates the supply of the vaporized precursors from the AMPDS1-3 at respective predetermined temperatures and respective predetermined flow rates to the showerhead 106. Thus, each AMPDS 118 can supply a respective vaporized precursor at a respective predetermined temperature and a respective predetermined flow rate to the showerhead 106. That is, the temperatures and flow rates of the vaporized precursors supplied by each AMPDS in the AMPDS1-3 are independently controlled and can be different from each other.

[0067] Further, the system controller 128 can control the controllers 204 of the AMPDS1-3 to supply the vaporized precursors in a sequence or in different combinations to the showerhead 106. Furthermore, the system controller 128 can control the AMPDS0 and the AMPDS1-3 such that the vaporized precursors from the

AMPDS0 and the AMPDS1-3 are supplied to the showerhead 106 in a sequence or in different combinations. Thus, the AMPDS0 and the AMPDS1-3 can supply up to four vaporized precursors to the showerhead 106 at independently controlled temperatures and flow rates and in a sequence or in different combinations.

- 5 **[0068]** Further, in the AMPDS 118, the controller 204 controls the valves 202 to supply a purge gas (e.g., an inert gas) through the showerhead 106 into the station 102. The purge gas may be the same as the carrier gas, which is also an inert gas, or may be a different gas supplied by the gas sources 112. For example, in some processes, the purge gas is supplied after supplying one vaporized precursor and before supplying a
- 10 next dose of the same vaporized precursor or another vaporized precursor. In these processes, the controller 204 controls the sequencing of the vaporized precursor and the purge gas. Furthermore, the controller 204 controls the valves 202 to control the flow of the purge gas in order to prevent the vaporized precursor from one AMPDS from mixing with the vaporized precursor from another AMPDS upstream of each AMPDS.
- 15 **[0069]** In each AMPDS 118, the controller 204 controls the valves 202 in coordination with the system controller 128. In some processes, by controlling the valves 202 in each AMPDS 118, the controllers 204 of the AMPDSs and the system controller 128 can supply the vaporized precursors and the purge gas in different sequences. In some processes, by controlling the valves 202 in each AMPDS 118, the controllers 204 of the
- 20 AMPDSs and the system controller 128 can also supply the vaporized precursors in different combinations and can supply the different combinations of the vaporized precursors and the purge gas in different sequences.

SECTION 3: EXAMPLES OF CONFIGURATIONS OF AMPDSs

- 25 **[0070]** FIGS. 3A-3C show examples of different configurations of one of the multiple AMPDS1-3. Each AMPDS 118 in the assembly of the AMPDS1-3 can be configured using one of the configurations. The configurations are identical to that shown in FIG. 2 except for the following differences.

- 30 **[0071]** FIG. 3A shows a configuration of the AMPDS 118 that comprises the MFC 232 but does not comprise a pressure sensor 240 shown in FIG. 3B. FIG. 3B shows a configuration of the AMPDS 118 that comprises the pressure sensor 240 but does not comprise the MFC 232 shown in FIG. 3A. FIG. 3C shows a configuration of the AMPDS 118 comprising both the MFC 232 and the pressure sensor 240. Other details of the

AMPDS 118 shown in FIG. 2 are omitted but are presumed present in FIGS. 3A-3C and are not described again for brevity.

[0072] In FIG. 3A, the MFC 232 controls the flow rate of the vaporized precursor supplied from the AMPDS 118 to the showerhead 106 of the station 102. The AMPDS 118 further comprises valves 242 subsequent to the MFC 232. The valves 242 are connected between the MFC 232 and the conduit 234 that supplies the vaporized precursor from the AMPDS 118 to the showerhead 106 of the station 102. The controller 204 of the AMPDS 118 controls the valves 242 to start and stop the supply of the vaporized precursor from the AMPDS 118 to the showerhead 106 of the station 102.

[0073] The additional heaters described above with reference to FIG. 2 (and as shown and described below with reference to FIG. 4B) heat only some of the valves 202, the MFC 232, the conduit 234, and the valves 242. Further, the AMPDS 118 also comprises the thermal isolator (shown in FIG. 4B) that thermally isolates the heated valves 202, the MFC 232, the conduit 234, the valves 242 from the enclosure of the assembly (shown in FIGS. 5-6B) housing the AMPDS 118. Thus, the AMPDS 118 supplies the vaporized precursor at the predetermined temperature and the predetermined flow rate to the showerhead 106.

[0074] In FIG. 3B, the AMPDS 118 does not comprise the MFC 232. Instead, the AMPDS 118 comprises the pressure sensor 240 to control the flow rate of the vaporized precursor supplied from the AMPDS 118 to the showerhead 106 of the station 102. The pressure sensor 240 is connected to the conduit 230. The pressure sensor 240 is connected to the controller 204 of the AMPDS 118. Based on the pressure of the vaporized precursor in the conduit 230 sensed by the pressure sensor 240, the controller 204 controls the valves 202 that control the supply of the vaporized precursor to the showerhead 106 through the conduit 234. The AMPDS 118 does not comprises valves 242.

[0075] The additional heaters described above with reference to FIG. 2 (and as shown and described below with reference to FIG. 4A) heat only some of the valves 202 and the conduit 234 that supply the vaporized precursor supplied from the AMPDS 118 to the showerhead 106 of the station 102. Further, the AMPDS 118 also comprises the thermal isolator (shown in FIG. 4A) that thermally isolates the heated valves 202 and the conduit 234 from the enclosure of the assembly (shown in FIGS. 5-6B) housing the

AMPDS 118. Thus, the AMPDS 118 supplies the vaporized precursor at the predetermined temperature and the predetermined flow rate to the showerhead 106.

[0076] In FIG. 3C, the AMPDS 118 comprises the MFC 232 and the pressure sensor 240. The controller 204 controls the MFC 232 based on the pressure of the vaporized precursor in the conduit 230 sensed by the pressure sensor 240. the MFC 232 controls the flow rate of the vaporized precursor supplied from the AMPDS 118 to the showerhead 106 of the station 102. The AMPDS 118 further comprises valves 242 subsequent to the MFC 232. The controller 204 controls the valves 242 as described above with reference to FIG. 3A. The additional heaters that heat and the thermal isolator that thermally isolates some of the valves 202, the MFC 232, the conduit 234, and the valves 242 are already described above with reference to FIG. 3A and are not described again for brevity. Thus, the AMPDS 118 supplies the vaporized precursor at the predetermined temperature and the predetermined flow rate to the showerhead 106.

SECTION 4: EXAMPLES OF HEATERS AND THERMAL ISOLATORS

[0077] FIGS. 4A and 4B show examples of heating and thermally isolating of some of the valves 202, the MFC 232, the conduit 234, and the valves 242 used to supply the vaporized precursor from one of the multiple AMPDS1-3. When an AMPDS 118 in the assembly of the AMPDS1-3 is configured as shown in FIG. 3B, the heaters and the thermal isolator can be configured as shown in FIG. 4A. When an AMPDS 118 in the assembly of the AMPDS1-3 is configured as shown in FIGS. 3A and 3C, the heaters and the thermal isolator can be configured as shown in FIG. 4B. Other details of the AMPDS 118 shown in FIG. 2 are omitted but are presumed present in FIGS. 4A and 4B and are not described again for brevity.

[0078] In FIGS. 4A and 4B, the valve block comprising the manifold 206 and the valves 202 is shown in further detail. Specifically, valves 202-1 of the valves 202 that do not supply the vaporized precursor from the AMPDS 118 to the showerhead 106 are not heated. Only valves 202-2 of the valves 202 that supply the vaporized precursor from the AMPDS 118 to the showerhead 106 are heated. While not shown, the conduit 230 that supplies the vaporized precursor from the ampule 200 to the valves 202-2 is shielded by the heat shield 238 as shown in FIG. 2. The valves 202-2 are heated to maintain the temperature of the vaporized precursor.

[0079] In FIG. 4A, in addition to the valves 202-2, the conduit 234 that supplies the vaporized precursor from the AMPDS 118 to the showerhead 106 via the valves 202-2 is also heated to maintain the temperature of the vaporized precursor. The AMPDS 118 comprises a heater 250 to heat the valves 202-2 and the conduit 234. The power supply 220 (shown in FIG. 2) supplies power to the heater 250. The controller 204 controls the power supplied by the power supply 220 to the heater 250.

[0080] A thermal isolator 252 is disposed between the enclosure of the assembly (shown in FIGS. 5-6B) housing the AMPDS 118 and the heater 250, the portion of the manifold 206 on which the valves 202-2 are arranged and heated, and the conduit 234 that is heated by the heater 250. The thermal isolator 252 thermally isolates the heater 250, the heated valves 202-2 and the heated conduit 234 from the enclosure of the assembly housing the AMPDS 118. The thermal isolator 252 helps maintain the temperature of the vaporized precursor through the heated valves 202-2 and the heated conduit 234. Thus, the AMPDS 118 supplies the vaporized precursor at the predetermined temperature to the showerhead 106.

[0081] In FIG. 4B, in addition to the valves 202-2, the MFC 232, the valves 242, and the conduit 234 that supply the vaporized precursor from the AMPDS 118 to the showerhead 106 are heated to maintain the temperature of the vaporized precursor. The AMPDS 118 comprises the heater 250 to heat the valves 202-2, the MFC 232, the valves 242, and the conduit 234. The power supply 220 (shown in FIG. 2) supplies power to the heater 250. The controller 204 controls the power supplied by the power supply 220 to the heater 250.

[0082] The thermal isolator 252 is disposed between the enclosure of the assembly (shown in FIGS. 5-6B) housing the AMPDS 118 and the heater 250, the portion of the manifold on which the valves 202-2 are arranged and heated, and the MFC 232, the valves 242, and the conduit 234 that are heated by the heater 250. The thermal isolator 252 thermally isolates the heater 250, the heated valves 202-2, the MFC 232, the valves 242, and the conduit 234 from the enclosure of the assembly housing the AMPDS 118. The thermal isolator 252 helps maintain the temperature of the vaporized precursor through the heated valves 202-2, 242, the heated MFC 232, and the heated conduit 234. Thus, the AMPDS 118 supplies the vaporized precursor at the predetermined temperature to the showerhead 106.

[0083] The controller 204 also controls the valves 202 such that some of the valves 202 can be connected to one another via the manifold 206 in different ways. Using these connections, the purge gas can purge and exhaust the vaporized precursor from the AMPDS 118.

5 SECTION 5: ASSMEBLY COMPRISING MULTIPLE AMPDSs

[0084] FIGS. 5-6B show different views of an assembly comprising the multiple AMPDSs and arrangements of different components of the assembly. FIG. 5 shows a front view of the assembly. FIG. 6A shows a front cover of the assembly. FIG. 6B shows a back view of the assembly.

10 **[0085]** In FIG. 5, for example, three AMPDSs 118 are arranged in an enclosure 260. The three AMPDSs 118 are shown at 118-1, 118-2, 118-3 (collectively called the AMPDSs 118 and individually called the AMPDS 118). The ampules 200 of the respective AMPDSs 118 are shown at 200-1, 200-2, 200-3. The valves 202 of the respective AMPDSs 118 are shown at 202-1, 202-2, 202-3. The thermal isolators 252
15 of the respective AMPDSs 118 are shown at 252-1, 252-2, 252-3.

[0086] For example, the enclosure 260 is rectangular. The ampules 200 with respective heaters 218 (not shown) are arranged at the bottom of the enclosure 260. The valve blocks 202 are arranged at the top of the enclosure 260. While omitted, other components of the AMPDS 118 shown in FIGS. 2-4B are located in each AMPDS 118
20 in the enclosure 260 except those shown in FIG. 6B, which are located outside on a back panel 270 of the enclosure 260. The thermal isolators 252 are disposed between the valve blocks and the inside of the back panel of the enclosure 260 as shown and as described above with reference to FIGS. 4A and 4B.

[0087] Additional thermal isolators 262-1 and 262-2 (collectively the thermal isolators
25 262) are disposed between adjacent AMPDSs within the enclosure 260. Specifically, the thermal isolator 262-1 is disposed between AMPDS1 and AMPDS2, and the thermal isolator 262-2 is disposed between AMPDS2 and AMPDS3. The thermal isolators 262 thermally isolate each AMPDS from the adjacent (neighboring) AMPDS.

[0088] Specifically, the thermal isolator 262-1 thermally isolates AMPDS1 from
30 AMPDS2, and the thermal isolator 262-2 thermally isolates AMPDS2 from AMPDS3. Since each AMPDS can be configured to supply a respective vaporized precursor at a different temperature and the temperature for one AMPDS can differ significantly from

the temperature for another AMPDS, the thermal isolators 262 are used to thermally isolate one AMPDS from another AMPDS. The thermal isolators 262 are as wide as the depth of the enclosure 260 and as tall as the height of the enclosure 260. Thus, the thermal isolators 262 fully thermally isolate the AMPDSs from each other. The enclosure 260 comprises an exhaust 268 at the top right corner of the enclosure 260. The exhaust 268 is described below with reference to FIG. 6A.

[0089] FIG. 6A shows a front cover 264 for the enclosure 260. The front cover 264 and the enclosure 260 form the assembly that houses (encloses) the AMPDSs. The front cover 264 comprises a plurality of louvers 266 near the bottom end of the front cover 264. The louvers 266 provide airflow from the bottom to the top of the enclosure 260. The airflow exhausts any residual vaporized precursors, which can be toxic and flammable, from the enclosure 260 through the exhaust 268. The airflow serves an additional function described below with reference to FIG. 6B.

[0090] FIG. 6B shows a back view of the enclosure 260. On the outside of the back panel 270 of the enclosure 260, the controllers 204, the MFCs 222, and the power supplies 220 of the AMPDSs 118 are arranged as shown. The controllers 204 of the respective AMPDSs 118 are shown at 204-1, 204-2, 204-3. The MFCs 222 of the respective AMPDSs 118 are shown at 222-1, 222-2, 222-3. The power supplies 220 of the respective AMPDSs 118 are shown at 220-1, 220-2, 220-3.

[0091] The louvers 266 on the front cover 264 are on the opposite side of the controllers 204 and the power supplies 220, which are arranged on the outside of the back panel 270 of the enclosure 260. The airflow from the louvers 266 to the exhaust 268 prevents any residual vaporized precursors, which can be toxic and flammable, from causing a fire due to any sparking that may occur in the controllers 204 and the power supplies 220 of the AMPDSs 118.

[0092] The back panel 270 also comprises ports 272-1, 272-2, 272-3 (collectively the ports 272) of the respective AMPDSs 118. The conduits 234 of the respective AMPDSs 118 are connected to the respective ports 270. The ports 272 are connected to the showerhead 106 by the manifold 116 shown in FIG. 1.

SECTION 6: METHOD OF OPERATING AMPDSs

[0093] FIG. 7 shows a method 300 for operating the AMPDSs 118. The method 300 can be performed by the controllers 204 of the AMPDSs, the system controller 128, or

both. That is, some of the steps of the method 300 can be performed by the controllers 204 of the AMPDSs while some other steps of the method 300 can be performed by the system controller. Still other steps of the method 300 can be performed in a coordinated manner by both controllers 204 of the AMPDSs and the system controller 128.

- 5 **[0094]** At 302, different liquid precursors are supplied from the liquid sources 114 to the AMPDSs 118. At 304, the liquid precursors in the AMPDSs 118 are heated by the heaters 218 to respective temperatures as described above. At 306, a carrier gas is supplied from one of the gas sources 112 to the AMPDSs 118 via respective MFCs 222 at respective flow rates as described above.
- 10 **[0095]** At 308, the heaters 350 heat the valves 202-2, the MFCs 232, and the conduits 234 of the AMPDSs 118 as described above to maintain the respective temperatures of the vaporized precursors output from the AMPDSs 118. At 310, the vaporized precursors are output from the AMPDSs 118 in a sequence, in a sequences of some combinations, and in a sequence with the purge gas as described above.
- 15 **[0096]** At 312, the vaporized precursors are supplied from the AMPDSs 118 to the showerhead 106 at respective temperatures and flow rates as described above. At 314, the liquid precursors are replenished in the AMPDSs based on levels of the liquid precursors sensed in the AMPDSs as described above.
- 20 **[0097]** The foregoing description is merely illustrative in nature and is not intended to limit the disclosure, its application, or uses. The broad teachings of the disclosure can be implemented in a variety of forms. Therefore, while this disclosure includes particular examples, the true scope of the disclosure should not be so limited since other modifications will become apparent upon a study of the drawings, the specification, and the following claims.
- 25 **[0098]** It should be understood that one or more steps within a method may be executed in different order (or concurrently) without altering the principles of the present disclosure. Further, although each of the examples is described above as having certain features, any one or more of those features described with respect to any one of the examples of the disclosure can be implemented in and/or combined with features of
- 30 any of the other examples, even if that combination is not explicitly described. In other words, the described examples are not mutually exclusive, and permutations of one or more examples with one another remain within the scope of this disclosure.

[0099] Spatial and functional relationships between elements (for example, between modules, circuit elements, semiconductor layers, etc.) are described using various terms, including “connected,” “engaged,” “coupled,” “adjacent,” “next to,” “on top of,” “above,” “below,” and “disposed.” Unless explicitly described as being “direct,” when a relationship between first and second elements is described in the above disclosure, that relationship can be a direct relationship where no other intervening elements are present between the first and second elements, but can also be an indirect relationship where one or more intervening elements are present (either spatially or functionally) between the first and second elements. As used herein, the phrase at least one of A, B, and C should be construed to mean a logical (A OR B OR C), using a non-exclusive logical OR, and should not be construed to mean “at least one of A, at least one of B, and at least one of C.”

[0100] In some implementations, a controller is part of a system, which may be part of the above-described examples. Such systems can comprise semiconductor processing equipment, including a processing tool or tools, chamber or chambers, a platform or platforms for processing, and/or specific processing components (a wafer pedestal, a gas flow system, etc.). These systems may be integrated with electronics for controlling their operation before, during, and after processing of a semiconductor wafer or substrate.

[0101] The electronics may be referred to as the “controller,” which may control various components or subparts of the system or systems. The controller, depending on the processing requirements and/or the type of system, may be programmed to control any of the processes disclosed herein, including the delivery of processing gases, temperature settings (e.g., heating and/or cooling), pressure settings, vacuum settings, power settings, radio frequency (RF) generator settings, RF matching circuit settings, frequency settings, flow rate settings, fluid delivery settings, positional and operation settings, wafer transfers into and out of a tool and other transfer tools and/or load locks connected to or interfaced with a specific system.

[0102] Broadly speaking, the controller may be defined as electronics having various integrated circuits, logic, memory, and/or software that receive instructions, issue instructions, control operation, enable cleaning operations, enable endpoint measurements, and the like. The integrated circuits may include chips in the form of firmware that store program instructions, digital signal processors (DSPs), chips defined

as application specific integrated circuits (ASICs), and/or one or more microprocessors, or microcontrollers that execute program instructions (e.g., software).

[0103] Program instructions may be instructions communicated to the controller in the form of various individual settings (or program files), defining operational parameters for carrying out a particular process on or for a semiconductor wafer or to a system. The operational parameters may, in some examples, be part of a recipe defined by process engineers to accomplish one or more processing steps during the fabrication of one or more layers, materials, metals, oxides, silicon, silicon dioxide, surfaces, circuits, and/or dies of a wafer.

[0104] The controller, in some implementations, may be a part of or coupled to a computer that is integrated with the system, coupled to the system, otherwise networked to the system, or a combination thereof. For example, the controller may be in the “cloud” or all or a part of a fab host computer system, which can allow for remote access of the wafer processing. The computer may enable remote access to the system to monitor current progress of fabrication operations, examine a history of past fabrication operations, examine trends or performance metrics from a plurality of fabrication operations, to change parameters of current processing, to set processing steps to follow a current processing, or to start a new process.

[0105] In some examples, a remote computer (e.g., a server) can provide process recipes to a system over a network, which may include a local network or the Internet. The remote computer may include a user interface that enables entry or programming of parameters and/or settings, which are then communicated to the system from the remote computer. In some examples, the controller receives instructions in the form of data, which specify parameters for each of the processing steps to be performed during one or more operations. It should be understood that the parameters may be specific to the type of process to be performed and the type of tool that the controller is configured to interface with or control.

[0106] Thus, as described above, the controller may be distributed, such as by comprising one or more discrete controllers that are networked together and working towards a common purpose, such as the processes and controls described herein. An example of a distributed controller for such purposes would be one or more integrated circuits on a chamber in communication with one or more integrated circuits located

remotely (such as at the platform level or as part of a remote computer) that combine to control a process on the chamber.

5 [0107] Without limitation, example systems may include a plasma etch chamber or module, a deposition chamber or module, a spin-rinse chamber or module, a metal plating chamber or module, a clean chamber or module, a bevel edge etch chamber or module, a physical vapor deposition (PVD) chamber or module, a chemical vapor deposition (CVD) chamber or module, an atomic layer deposition (ALD) chamber or module, an atomic layer etch (ALE) chamber or module, an ion implantation chamber or module, a track chamber or module, and any other semiconductor processing systems
10 that may be associated or used in the fabrication and/or manufacturing of semiconductor wafers.

[0108] As noted above, depending on the process step or steps to be performed by the tool, the controller might communicate with one or more of other tool circuits or modules, other tool components, cluster tools, other tool interfaces, adjacent tools,
15 neighboring tools, tools located throughout a factory, a main computer, another controller, or tools used in material transport that bring containers of wafers to and from tool locations and/or load ports in a semiconductor manufacturing factory.

CLAIMS

What is claimed is:

1. An assembly for supplying vaporized precursors to a process module of a substrate processing system, the assembly comprising:
 - 5 a plurality of delivery systems disposed in an enclosure, each delivery system comprising:
 - a container comprising a liquid precursor;
 - a heater configured to heat the liquid precursor in the container; and
 - a conduit configured to supply a vaporized precursor generated in the
 - 10 container to the process module; and
 - a thermal isolator disposed in the enclosure between adjacent ones of the delivery systems to thermally isolate the adjacent ones of the delivery systems from each other.
2. The assembly of claim 1 wherein the liquid precursors of the delivery systems
- 15 are different from each other.
3. The assembly of claim 1 wherein the heaters of the delivery systems are configured to heat the liquid precursors to different temperatures.
4. The assembly of claim 1 wherein the delivery systems are configured to output the vaporized precursors from the respective conduits at different flow rates.
- 20 5. The assembly of claim 1 wherein the delivery systems are configured to output the vaporized precursors from the respective conduits at different temperatures and different flow rates.
6. The assembly of claim 1 wherein the liquid precursors of the delivery systems are different from each other and wherein the delivery systems are configured to output
- 25 the vaporized precursors from the respective conduits at different temperatures and different flow rates.

7. The assembly of claim 1 wherein each delivery system further comprises a controller configured to control a temperature and a flow rate of the vaporized precursor output from the conduit.
8. The assembly of claim 1 wherein the heaters of the delivery systems are
5 configured to heat the liquid precursors of the delivery systems to different temperatures.
9. The assembly of claim 1 wherein each delivery system further comprises:
a power supply configured to supply power to the heater; and
a controller configured to control the power supplied by the power supply to the
10 heater to heat the liquid precursor to a predetermined temperature.
10. The assembly of claim 1 further comprising a plurality of mass flow controllers configured to supply a gas to the delivery systems at predetermined flow rates, respectively.
11. The assembly of claim 1 wherein at least one of the delivery systems further
15 comprises a mass flow controller configured to control a flow rate of the vaporized precursor output from the conduit.
12. The assembly of claim 1 wherein at least one of the delivery systems further comprises:
a pressure sensor configured to sense a pressure of the vaporized precursor
20 exiting the container; and
a controller configured to control a flow rate of the vaporized precursor output from the conduit based on the sensed pressure.

13. The assembly of claim 1 wherein each delivery system further comprises:
a valve and a mass flow controller coupled to the conduit;
a second heater coupled to the valve, the mass flow controller, and the conduit;
and
5 a second thermal isolator disposed between a surface of the enclosure and the second heater, the valve, the mass flow controller, and the conduit to thermally isolate the second heater, the valve, the mass flow controller, and the conduit from the surface of the enclosure.
14. The assembly of claim 13 wherein each delivery system further comprises:
10 a power supply configured to supply power to the heater; and
a controller configured to control the power supplied to the heater to maintain a temperature of the vaporized precursor in the valve, the mass flow controller, and the conduit.
15. The assembly of claim 1 wherein each delivery system further comprises:
15 a valve coupled to the conduit;
a second heater coupled to the valve and the conduit; and
a second thermal isolator disposed between a surface of the enclosure and the second heater, the valve, and the conduit to thermally isolate the second heater, the valve, and the conduit from the surface of the enclosure.
- 20 16. The assembly of claim 15 wherein each delivery system further comprises:
a power supply configured to supply power to the heater; and
a controller configured to control the power supplied to the heater to maintain a temperature of the vaporized precursor in the valve and the conduit.
- 25 17. The assembly of claim 1 wherein each delivery system further comprises:
a second conduit configured to supply the vaporized precursor from the container to a valve, wherein the conduit is coupled to the valve; and
a heat shield disposed around the heater, the container, and the second conduit.

18. The assembly of claim 1 further comprising:
a cover disposed on a first side of the assembly;
a plurality of louvers provided on the cover; and
an exhaust port provided on the assembly.
- 5 19. The assembly of claim 18 wherein each delivery system further comprises:
a power supply configured to supply power to the heater; and
a controller configured to control the power supplied by the power supply to the
heater to heat the liquid precursor to a predetermined temperature;
wherein the assembly further comprises a plurality of mass flow controllers
10 configured to supply a gas to the plurality of delivery systems, respectively; and
wherein the power supplies, the controllers, and the mass flow controllers are
disposed outside the assembly and are disposed on a second side of the assembly that
is opposite to the first side of the assembly.
- 15 20. The assembly of claim 1 wherein each delivery system further comprises a
controller configured to control a temperature and a flow rate of the vaporized precursor
output from the conduit and wherein the controllers are configured to control a
sequence in which the vaporized precursors are output from the delivery systems.
- 20 21. The assembly of claim 20 wherein the controllers are configured to control the
delivery systems to output the vaporized precursors from the respective conduits in the
sequence at different flow rates.
22. The assembly of claim 20 wherein the controllers are configured to control the
delivery systems to output the vaporized precursors from the respective conduits in the
sequence at different temperatures and different flow rates.
- 25 23. The assembly of claim 20 wherein the liquid precursors of the delivery systems
are different from each other and wherein the controllers are configured to control the
delivery systems to output the vaporized precursors from the respective conduits in the
sequence at different temperatures and different flow rates.

24. The assembly of claim 1 wherein each delivery system further comprises a controller configured to control a temperature and a flow rate of the vaporized precursor output from the conduit and wherein the controllers are configured to control at least two of the delivery systems to concurrently output the respective vaporized precursors from the respective conduits.

25. The assembly of claim 24 wherein the controllers are configured to control the at least two of the delivery systems to concurrently output the vaporized precursors from the respective conduits at different flow rates.

26. The assembly of claim 24 wherein the controllers are configured to control the at least two of the delivery systems to concurrently output the vaporized precursors from the respective conduits at different temperatures and different flow rates.

27. The assembly of claim 24 wherein the liquid precursors of the delivery systems are different from each other and wherein the controllers are configured to control the at least two of the delivery systems to concurrently output the vaporized precursors from the respective conduits at different temperatures and different flow rates.

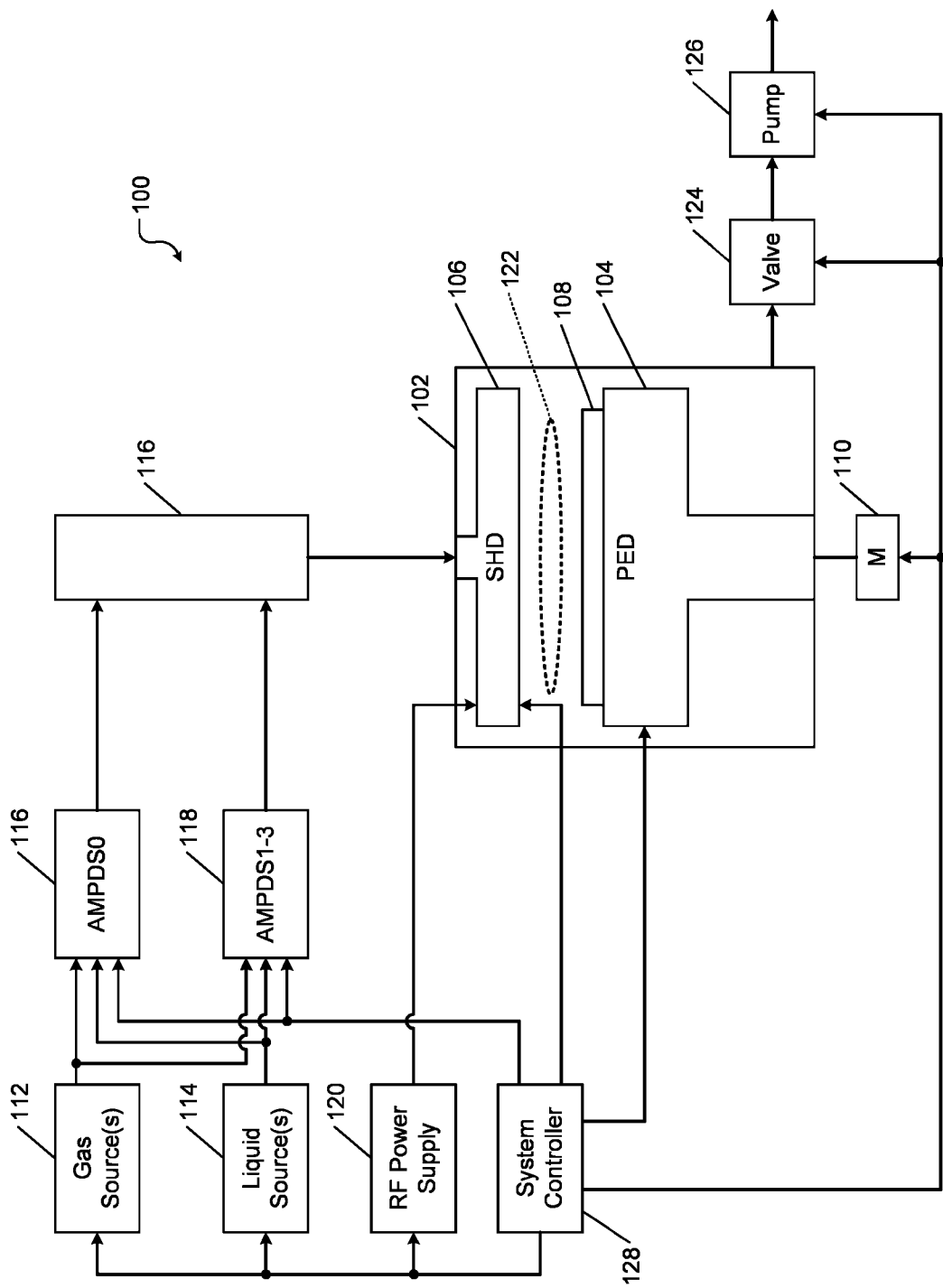


FIG. 1

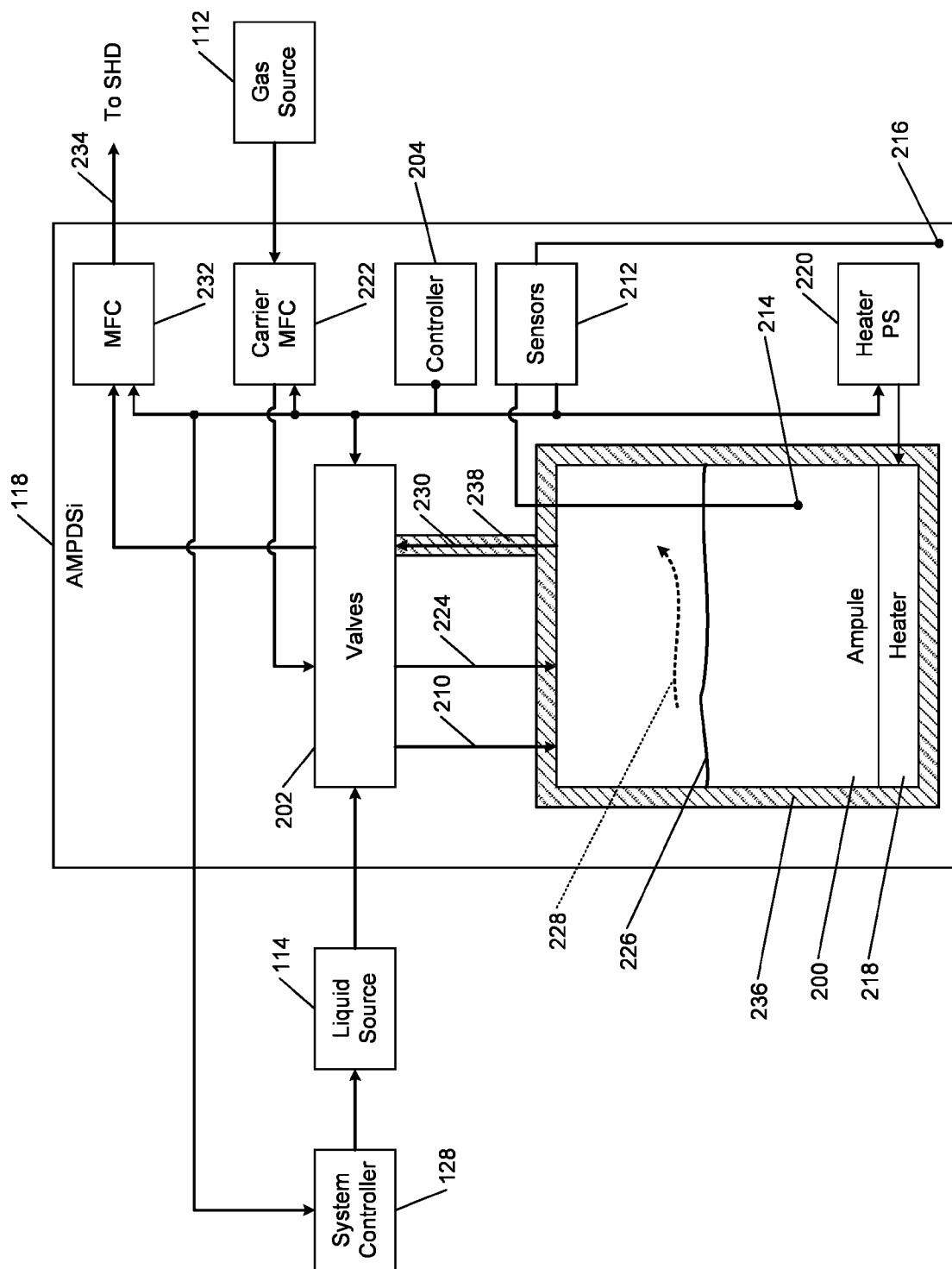


FIG. 2

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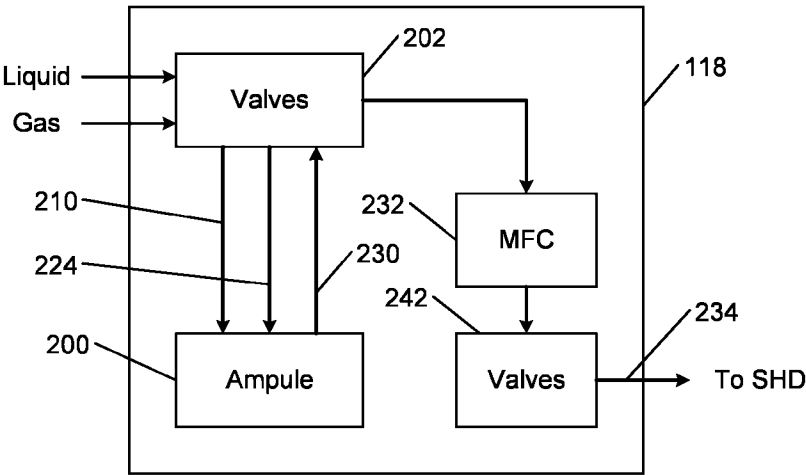


FIG. 3A

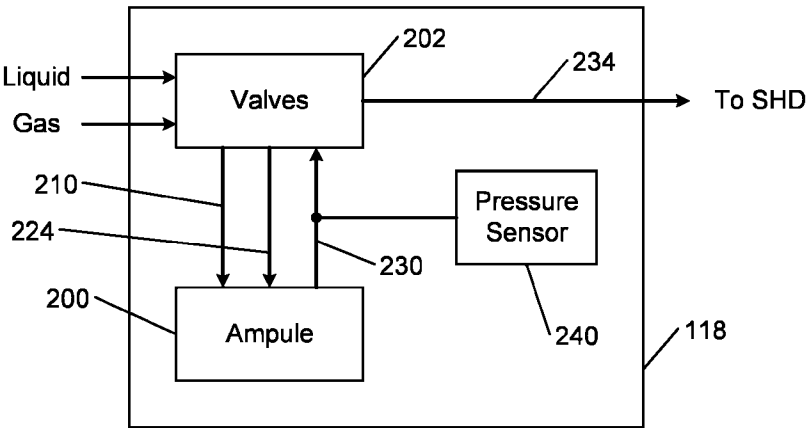


FIG. 3B

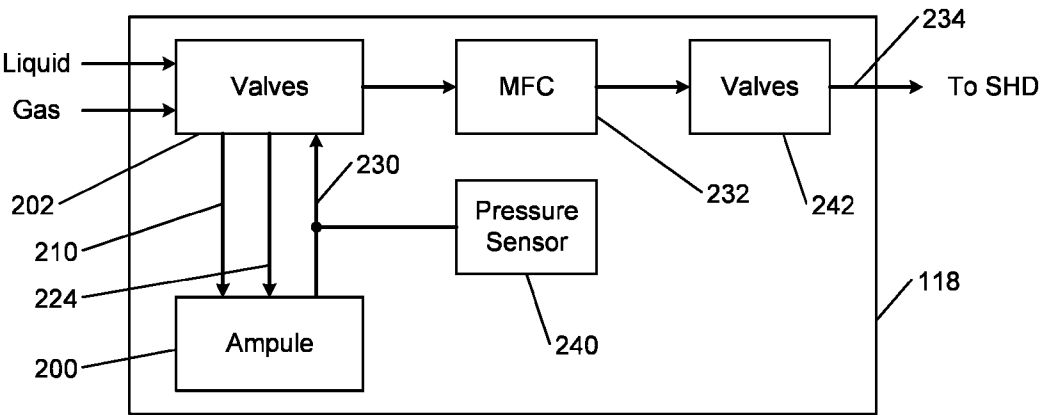


FIG. 3C

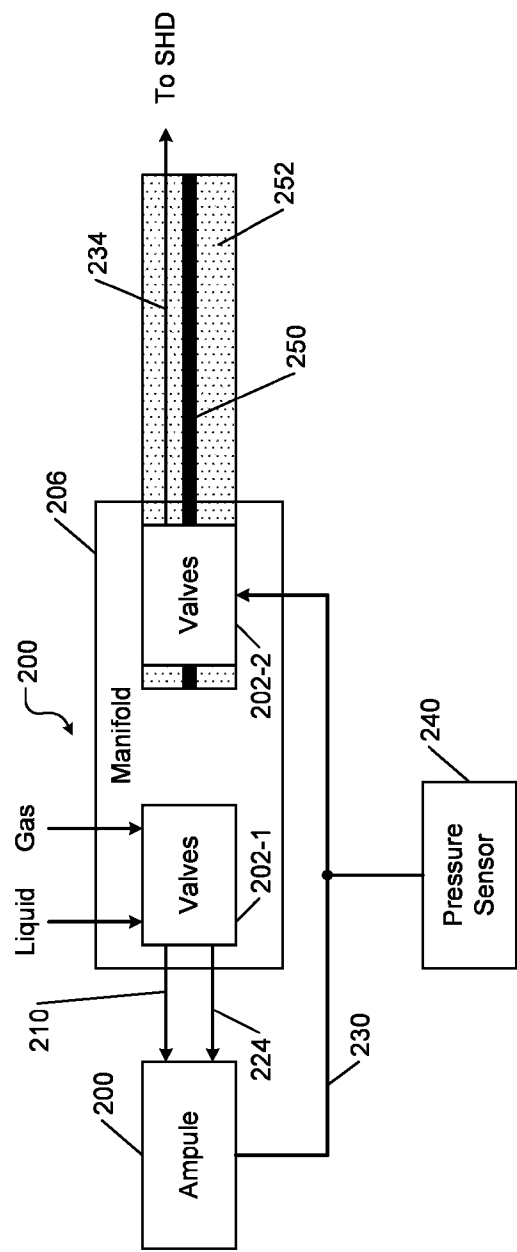


FIG. 4A

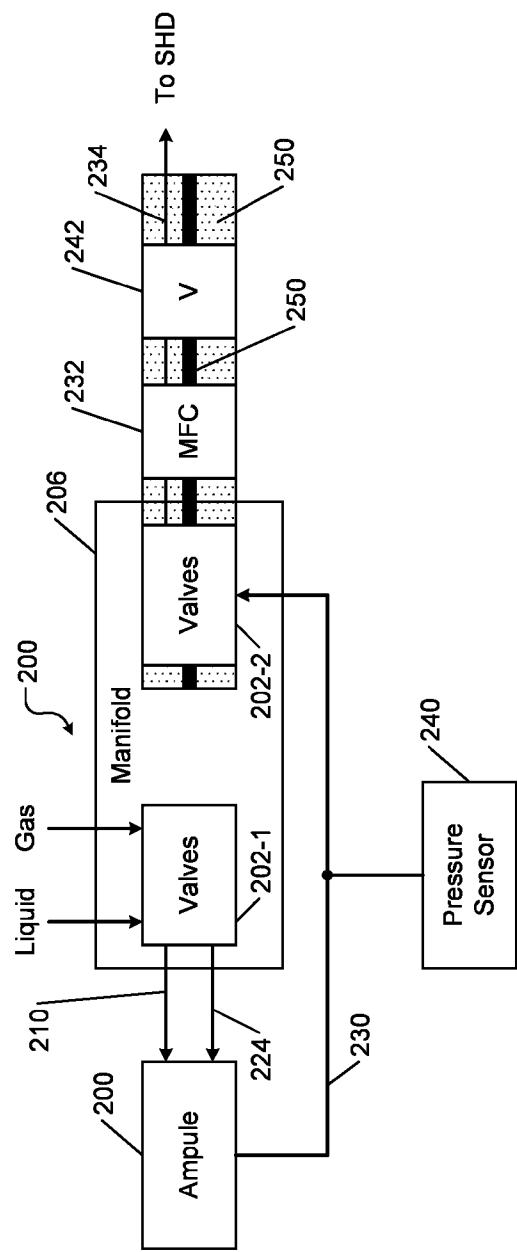


FIG. 4B

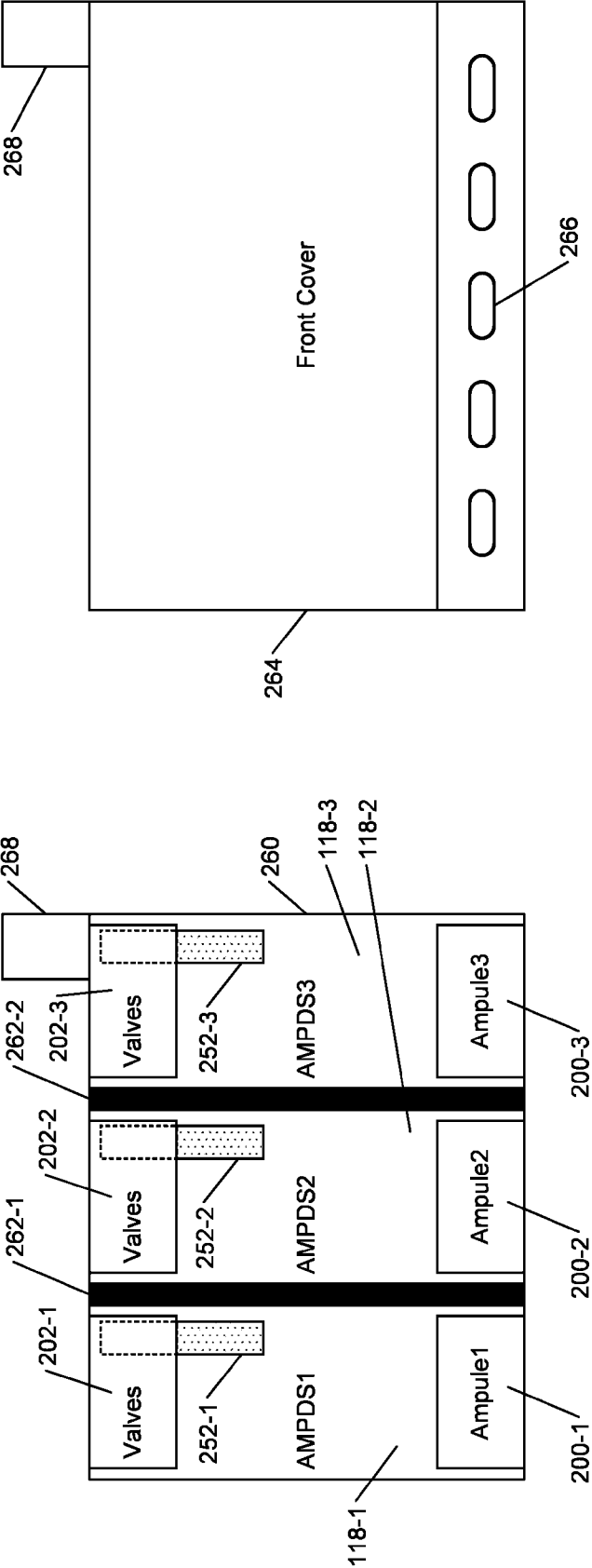


FIG. 5

FIG. 6A

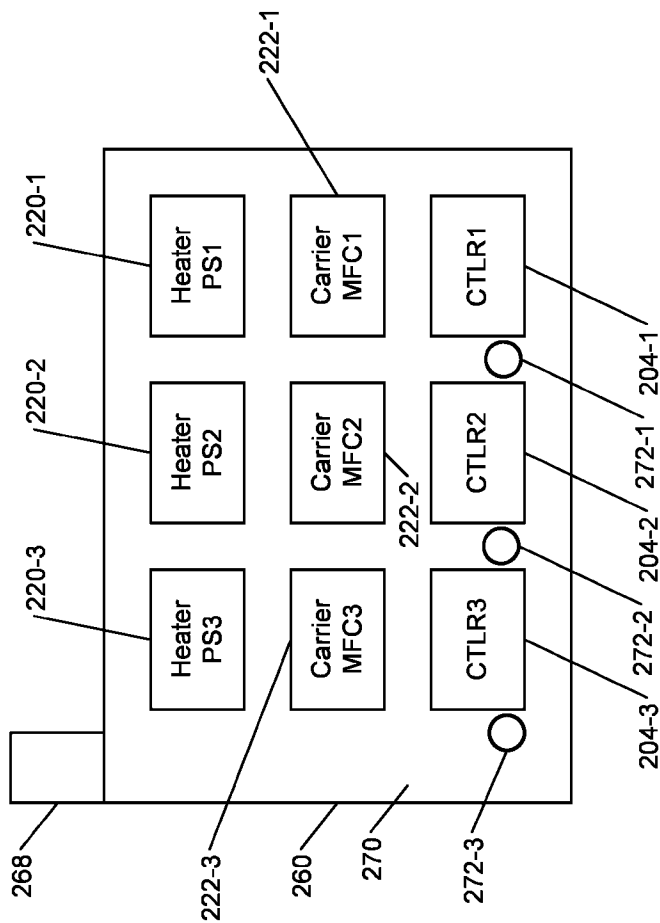


FIG. 6B

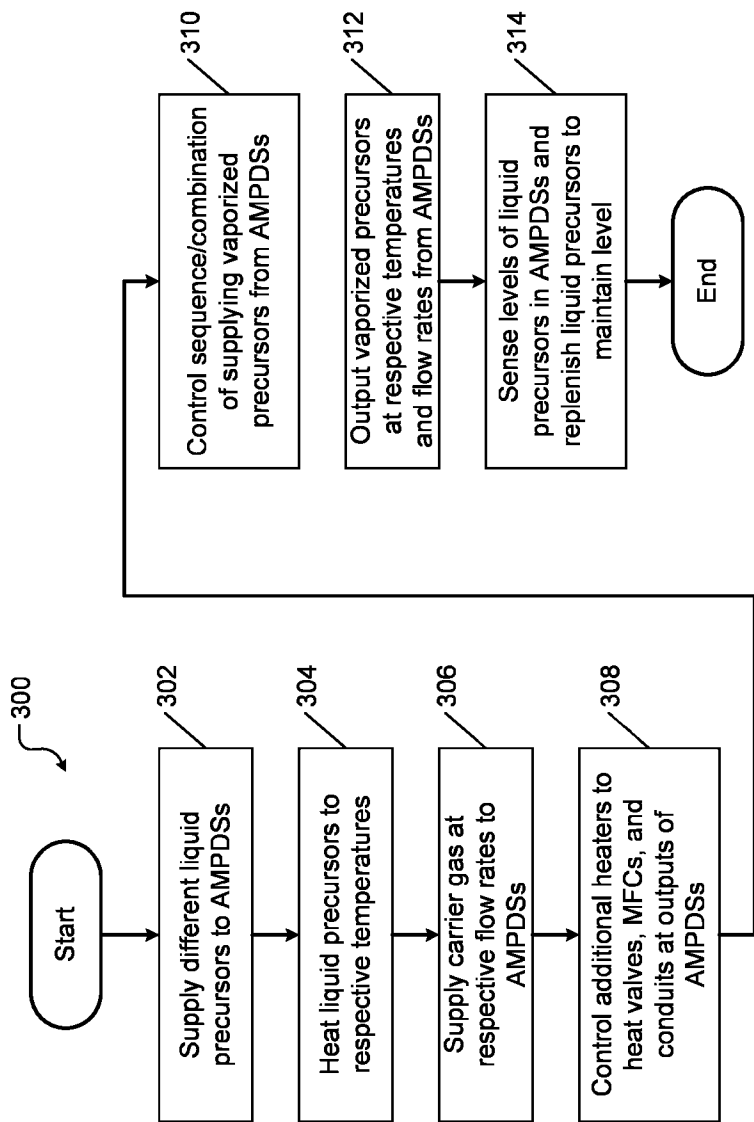


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2024/033192

A. CLASSIFICATION OF SUBJECT MATTER H01L 21/67(2006.01)i; C23C 16/448(2006.01)i; C23C 16/52(2006.01)i; H01J 37/32(2006.01)i According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) H01L 21/67(2006.01); C23C 16/08(2006.01); C23C 16/44(2006.01); C23C 16/448(2006.01); C23C 16/455(2006.01); C23C 16/52(2006.01); C23C 16/54(2006.01) Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Korean utility models and applications for utility models Japanese utility models and applications for utility models Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS(KIPO internal) & Keywords: precursor, ampoule, enclosure, heater, thermal isolator		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	US 2023-0068384 A1 (ENTEGRIS, INC.) 02 March 2023 (2023-03-02) paragraphs [30]-[40] and figures 1-2	1-12,17,20-27 13-16,18-19
Y	US 2023-0019511 A1 (TAIWAN SEMICONDUCTOR MANUFACTURING COMPANY LIMITED) 19 January 2023 (2023-01-19) paragraphs [21]-[44] and figure 1B	1-12,17,20-27
Y	EP 2628821 A1 (PICOSUN OY) 21 August 2013 (2013-08-21) paragraphs [42]-[45] and figure 3	9-10,17
A	US 2008-0220164 A1 (HARTMUT BAUCH et al.) 11 September 2008 (2008-09-11) claims 1-9 and figures 3-4	1-27
A	US 2018-0163307 A1 (APPLIED MATERIALS, INC.) 14 June 2018 (2018-06-14) paragraphs [37]-[44] and figures 3A-3B	1-27
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “D” document cited by the applicant in the international application “E” earlier application or patent but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed “T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art “&” document member of the same patent family		
Date of the actual completion of the international search 12 September 2024		Date of mailing of the international search report 12 September 2024
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon 35208, Republic of Korea Facsimile No. +82-42-481-8578		Authorized officer YANG, Seong Ji Telephone No. +82-42-481-3362

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/US2024/033192

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				EP	2628820	A1	21 August 2013
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				EP	2628821	B1	30 May 2018
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