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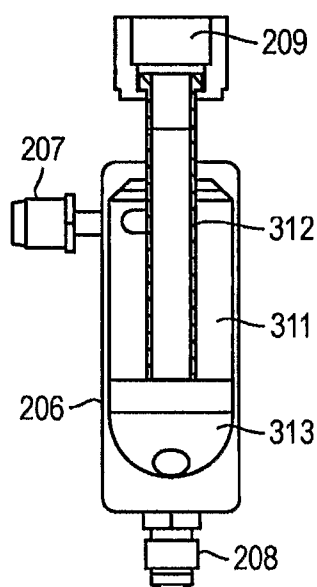
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(54) Title: SYSTEM AND METHOD FOR VORTEX CONDENSATION TRAPPING IN PURGE GAS HUMIDIFICATION



(57) Abstract: In one embodiment according to the invention, there is disclosed a purge gas humidification system. The system comprises a moisturizer configured to add moisture to a purge gas; and a condensation trap (206) comprising an inlet (207) configured to receive humidified purge gas from the moisturizer, a water drain (208) configured to drain excess condensed water from the condensation trap, and an outlet (209) configured to output humidified purge gas from the condensation trap. The condensation trap is configured to induce a substantially vortex flow pattern in the humidified purge gas received from the moisturizer.



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SYSTEM AND METHOD FOR VORTEX CONDENSATION TRAPPING IN PURGE GAS HUMIDIFICATION

RELATED APPLICATIONS

This application claims the benefit of and priority to U.S. Provisional
5 Application No. 60/838,676, filed on August 18, 2006. The entire teachings of the
above application(s) are incorporated herein by reference.

BACKGROUND OF THE INVENTION

In general, surfaces of components present in a lithographic projection
apparatus become contaminated during use, even if most of the apparatus is
10 operated in vacuum. In particular, the contamination of optical components in a
lithographic projection apparatus, such as mirrors, has an adverse effect on the
performance of the apparatus, because such contamination affects the optical
properties of the optical components.

It is known that contamination of optical components of a lithographic
15 projection apparatus can be reduced by purging a space of the lithographic
projection apparatus in which such a component is located with an ultra high purity
gas, referred to as a purge gas. The purge gas prevents contamination of the surface,
such as molecular contamination of the surface with hydrocarbons.

A drawback of this method is that the purge gas may have an adverse effect
20 on the activity of chemicals used in the lithographic projection process. It has been
found that some types of radiation-sensitive material (resists), in particular, resists
sensitive to ultra-violet radiation and acetal-base photo-resists, do not function
properly in an environment provided with the purge gas and that these resists require
moisture, e.g., water vapor, to develop. Furthermore, the purge gas may have an
25 effect on the performance of measurement devices present in a lithographic
projection apparatus, such as interferometric instruments. It has been found that
because of the lack of moisture, the purge gas affects the refractive index and
thereby changes the outcome of interferometric measurements as well.

In order to prevent such effects that result from a dry purge gas, it has been
30 found that certain devices, known as membrane contactors, are useful for adding
moisture to the purge gas. In such membrane contactors, the purge gas does not
contact liquid water, but is infused with water vapor through a gas-permeable
membrane that is substantially resistant to liquid intrusion.

- 2 -

However, although existing purge gas humidification techniques reduce contamination in lithographic projection without affecting the development of the resist, there is an ongoing need to improve such techniques for humidifying purge gas.

SUMMARY OF THE INVENTION

In one embodiment according to the invention, there is provided a purge gas humidification system. The system comprises a moisturizer configured to add moisture to a purge gas; and a condensation trap comprising an inlet configured to receive humidified purge gas from the moisturizer, a water drain configured to drain excess condensed water from the condensation trap, and an outlet configured to output humidified purge gas from the condensation trap. The condensation trap is configured to induce a substantially vortex flow pattern in the humidified purge gas received from the moisturizer.

In further related embodiments, an outlet tube of the condensation trap can be configured to support a fluid dynamic path around its outside surface such that the substantially vortex flow pattern is induced. A flow volume of the outlet tube can be larger than a flow volume of the inlet of the condensation trap. The inlet of the condensation trap can be tangentially-offset from a radial axis of the condensation trap. An inlet tube of the condensation trap can enter the condensation trap perpendicular to a longitudinal axis of the condensation trap. An outlet tube of the condensation trap can be parallel to the longitudinal axis of the condensation trap; and a central axis of the water drain of the condensation trap can be parallel to the longitudinal axis of the condensation trap. The moisturizer can comprise a first region containing a purge gas flow and a second region containing water wherein the first and second regions are separated by a gas-permeable membrane that is substantially resistant to liquid intrusion. The membrane can comprise a perfluorinated polymer. The moisturizer can comprise: a) a bundle of a plurality of gas-permeable hollow fiber membranes having a first end and a second end, said membranes having an outer surface and an inner surface, said inner surface comprising one of the first and second regions; b) each end of said bundle potted with a liquid tight seal forming an end structure with a surrounding housing wherein

- 3 -

the fiber ends are open to fluid flow; c) said housing having an inner wall and an outer wall, wherein the inner wall defines the other of the first and second regions between the inner wall and the hollow fiber membranes; d) said housing having a purge gas inlet connected to a purge gas source and a purge gas mixture outlet; and
5 e) said housing having a water inlet connected to a water source and a water outlet, wherein either the purge gas inlet is connected to the first end of the bundle and the purge gas mixture outlet is connected to the second end of the bundle or the water inlet is connected to the first end of the bundle and the water outlet is connected to the second end of the bundle. The purge gas humidification system can further
10 comprise a heating device configured to heat the moisturizer. The purge gas humidification system can be capable of operation at a purge gas flow rate of at least about 60 standard liters per minute and producing output humidified purge gas at a relative humidity percentage value of at least about 75%.

In another embodiment according to the invention, there is provided a
15 method of humidifying a purge gas. The method comprises passing the purge gas through a moisturizer for a period sufficient to humidify the purge gas; passing humidified purge gas output from the moisturizer into a condensation trap; flowing the humidified purge gas through the condensation trap in a substantially vortex flow pattern; draining excess condensed water from the condensation trap; and
20 outputting humidified purge gas from the condensation trap.

In further related embodiments, the method can further comprise flowing the humidified purge gas in a fluid dynamic path around an outside surface of an outlet tube of the condensation trap to induce the substantially vortex flow pattern. A flow volume of the outlet tube can be larger than a flow volume of an inlet of the
25 condensation trap. The humidified purge gas can be passed into the condensation trap through an inlet that is tangentially-offset from a radial axis of the condensation trap. The inlet can be perpendicular to a longitudinal axis of the condensation trap. The humidified purge gas can be output from the condensation trap through an outlet tube that is perpendicular to the longitudinal axis of the condensation trap. Excess
30 condensed water can be drained from the condensation trap through a water drain having a central axis that is parallel to the longitudinal axis of the condensation trap.

- 4 -

In a further embodiment according to the invention, there is provided a lithographic projection apparatus, comprising: an illuminator configured to provide a projection beam of radiation; a support structure configured to support a patterning device, the patterning device configured to pattern the projection beam according to a desired pattern; a substrate table configured to hold a substrate; a projection system configured to project the patterned beam onto a target portion of the substrate; and at least one purge gas supply system configured to provide a purge gas to at least part of the lithographic projection apparatus. The at least one purge gas supply system comprises a purge gas mixture generator comprising a moisturizer configured to add moisture to a purge gas, and a condensation trap comprising an inlet configured to receive humidified purge gas from the moisturizer, a water drain configured to drain excess condensed water from the condensation trap, and an outlet configured to output humidified purge gas from the condensation trap, wherein the condensation trap is configured to induce a substantially vortex flow pattern in the humidified purge gas received from the moisturizer. The purge gas supply system also comprises a purge gas mixture outlet connected to the purge gas mixture generator configured to supply the purge gas mixture to the at least part of the lithographic projection apparatus.

In another embodiment according to the invention, there is provided a method for providing a purge gas to at least part of a lithographic projection apparatus comprising an illuminator configured to provide a projection beam of radiation; a support configured to support a patterning device, the patterning device configured to pattern the projection beam according to a desired pattern; a substrate table configured to hold a substrate; and a projection system configured to project the patterned beam onto a target portion of the substrate. The method comprises generating a purge gas mixture that comprises at least one purge gas and moisture by adding moisture to a purge gas with a moisturizer and removing excess condensation from the purge gas with a condensation trap, wherein the condensation trap comprises an inlet configured to receive humidified purge gas from the moisturizer, a water drain configured to drain excess condensed water from the condensation trap, and an outlet configured to output humidified purge gas from the condensation trap, wherein the condensation trap is configured to induce a substantially vortex

- 5 -

flow pattern in the humidified purge gas received from the moisturizer. The method further comprises supplying the purge gas mixture to at least a part of the lithographic projection apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

5 The foregoing will be apparent from the following more particular description of example embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating embodiments of the present invention.

10 Fig. 1 shows a prior art condensation trap used to remove excess condensation from the purge gas provided by a controlled humidity source for a lithography apparatus.

 Fig. 2 is an outside view of a vortex condensation trap according to an embodiment of the invention.

15 Fig. 3A is a side view of the vortex condensation trap of Fig. 2, in accordance with an embodiment of the invention.

 Figs. 3B and 3C are cross-sections of the vortex condensation trap of Fig. 2, in accordance with an embodiment of the invention.

20 Fig. 4 shows a purge gas humidification system for evaluating performance of a vortex condensation trap according to an embodiment of the invention.

 Fig. 5 schematically depicts a lithographic projection apparatus in which a controlled humidity source using a vortex condensation trap according to an embodiment of the present invention may be used.

25 Fig. 6 shows a projection system and a radiation system that can be used in the lithographic projection apparatus of Fig. 5.

 Fig. 7 shows an exemplary embodiment of a purge gas supply system, in which a vortex condensation trap according to an embodiment of the invention may be used.

30 Fig. 8 shows a diagram of a moisturizer that may be used with a vortex condensation trap according to an embodiment of the invention.

 Fig. 9 is an outside view of a controlled humidity source using a vortex condensation trap according to an embodiment of the invention.

- 6 -

DETAILED DESCRIPTION OF THE INVENTION

In humidifying a purge gas for use in a lithographic projection apparatus, it is preferable to provide high humidity levels in the purge gas, but without introducing condensed water droplets into the gas. Condensed water in the purge gas may enter the lithography tool, and may affect the performance of the manufacturing process. Water droplets can pass through the space where interferometers measure the exact distance of objects (such as the wafer and reticle), thereby causing misalignment issues. In addition, water droplets that appear on the surface of the reticle or wafer being processed can change the refractive index of the light generated by the lithography tool, thereby causing variations in the printing process that lead to decreased manufacturing yields. Further, if the level of humidity in the purge gas is unstable and does not match the humidity level of the clean room in which the lithography tool is operating, humidity may diffuse from the tool into the clean room, thereby changing interferometer readings and causing misalignment issues and decreased manufacturing yields. Thus, there is a need to provide techniques of humidifying a purge gas that produce stable humidity levels, in a desirable relative humidity range, without introducing condensed water droplets into the gas.

Fig. 1 shows a prior art condensation trap 100 used to remove excess condensation from the purge gas provided by a controlled humidity source (CHS) for a lithography apparatus. The water condensation trap 100 of Fig. 1 uses a one-quarter inch stainless steel tube inlet 101 welded with a 90-degree bend 102 that turns the inlet purge gas towards the bottom of the trap. Moisturized purge gas enters through inlet 101, is turned towards the bottom of the trap by 90-degree bend 102, and enters an interior space 103 of the condensation trap. Condensed water droplets collect at water drain 104, and humidified purge gas, with excess condensation removed, exits through gas outlet 105. However, the design of Fig. 1 has some drawbacks for condensation removal, caused by gas channeling within the vessel. Gas emerging from the inlet tube 101 is directed at the water drain 104, which tends to prevent excess condensation from properly exiting through the water drain 104. Furthermore, this feature also causes water to accumulate in the interior 103 of the condensation trap over time, thereby causing Relative Humidity (RH) instability and producing water droplets in the purge gas exiting gas outlet 105.

- 7 -

Fig. 2 is an outside view of a vortex condensation trap 206 according to an embodiment of the invention. It has been found that such a vortex condensation trap 206 allows humidifying a purge gas with stable humidity levels, in a desirable relative humidity range, without introducing condensed water droplets into the gas. A humidified purge gas inlet 207 introduces humidified purge gas into the trap 206, and is positioned off-center, towards the edge of the trap 206, in order to produce a vortex flow pattern of the humidified purge gas within the trap 206. Excess condensation is removed from the trap 206 at water drain 208, and humidified purge gas with excess condensation removed exits through trap outlet 209.

Fig. 3A is a side view of the vortex condensation trap 206 of Fig. 2, in accordance with an embodiment of the invention, indicating cross-sections A-A and B-B. Fig. 3B shows cross-sectional view A-A of the vortex condensation trap 206, and Fig. 3C shows cross-sectional view B-B. As can be seen from Figs. 3B and 3C, the humidified purge gas inlet 207 is positioned off-center, towards the edge of the trap 206 with its end 310 (see Fig. 3C) extending into the interior 311 of the trap 206, behind an outlet tube 312 in Fig. 3B. For example, the inlet 207 may be tangentially-offset from a radial axis of the condensation trap 206. The tube portion of the inlet 207 may be formed, for example, of a one-quarter inch diameter stainless steel tube. The outlet tube 312 is connected to trap outlet 209, and may be formed, for example, of a one-half inch diameter stainless steel tube. Other sizes may be used for the inlet 207, outlet 209 and other components, depending on the application, as will be apparent to those of skill in the art. Condensed water droplets are collected in the bottom 313 of the vessel interior 311 and exit through water drain 208.

The vortex condensation trap 206 of the embodiments of Figs. 2 and 3A-3C effectively removes more excess condensation in the purge gas, and attains a higher and more stable Relative Humidity (RH) output than the prior art condensation trap of Fig. 1. The vortex condensation trap 206 prevents condensed water droplets from re-entering the purge gas by using gravitational and centrifugal effects produced by a substantially vortex flow pattern of humidified purge gas within the condensation trap 206. Because the inlet 207 is positioned adjacent to the trap walls, the inlet tends to initiate vortex flow within the trap 206. Excess condensation in the purge

- 8 -

gas contacts the inside walls of the trap 206 and is spread across the surface area of the inside walls of the trap 206, instead of collecting at the bottom of the trap as in the prior art condensation trap of Fig. 1. Thus, the vortex trap 206 increases the water evaporation rate, by increasing the contact surface area between the water
5 condensation and the humid purge gas as compared with the prior art condensation trap of Fig. 1. The vortex flow pattern within the trap 206 is supported by the positioning of the outlet tube 312, which is shown positioned centrally in Fig. 3B with the end 310 of the inlet tube 207 emerging behind it. Because of the relative positioning of the inlet tube 207 and the outlet tube 312, the outlet tube 312 controls
10 the flow of humidified purge gas within the vessel to support a fluid dynamic path around its outside surface, thereby producing a vortex formation in the flow pattern. The humidified purge gas flows in a circular pattern in the vertically downward direction within the trap 206, which aids in separating excess moisture as gravitational forces carry the heavier water condensation particles out of the
15 humidified purge gas and towards the water drain 208. Further, the circular flow pattern does not cause gas channeling to push the collected water away from the water drain 208, as occurred in the prior art condensation trap of Fig. 1. Thus, the vortex flow pattern uses both gravitational and centrifugal forces to effectively separate the water condensation and send it to the drain 208. In one embodiment,
20 the vortex flow pattern may be aided by having the inlet tube 207 enter the condensation trap 206 perpendicular to a longitudinal axis of the condensation trap 206, while the outlet tube 312 and the central axis of the water drain 208 are parallel to the longitudinal axis of the condensation trap 206.

In accordance with an embodiment of the invention, the outlet tube 312 may
25 be a large volume outlet, such as a one-half inch diameter stainless steel tube. Because the outlet tube 312 provides a larger outlet flow volume than the flow volume of inlet 207, it may prevent condensation build-up within the outlet purge gas. Also, the pressure drop is reduced across the condensation trap 206, which may affect the amount of moisture that can be added to the purge gas stream and produce
30 a higher humidity purge gas. The larger outlet flow volume of outlet tube 312 may slow the purge gas flow rate, thereby reducing cooling, which causes condensation to form within the trap and be removed from the purge gas.

- 9 -

Also in accordance with an embodiment of the invention, the vortex condensation trap 206 may be compact in size and fit within existing Controlled Humidity Source (CHS) systems. Such compact size is advantageous because of the high cost associated with a larger device footprint in a lithography clean room.

5 A vortex condensation trap according to an embodiment of the invention is useful in semiconductor manufacturing applications generally; and is particularly useful in immersion lithography applications, in which high relative humidities are required in a purge gas. A vortex condensation trap according to an embodiment of the invention is also useful for double exposure and double patterning lithography applications, in which the requirement of aligning both exposures over the same
10 position increases the demand for correct alignment. Since humidified purge gas without excess condensation helps to avoid misalignment issues, an embodiment according to the invention is useful in such applications.

Fig. 4 shows a controlled humidity system for evaluating performance of a
15 vortex condensation trap 206 according to an embodiment of the invention. In the system of Fig. 4, vortex condensation trap 206 produced increased water vapor and increased humidity level stability in the purge gas output stream, by comparison with the prior art condensation trap of Fig. 1. A 10M stainless steel body 414 was filled with deionized water from a Milli-Q® water system 415, sold by Millipore Corporation of Billerica, MA. The vessel 414 was pressurized with purified
20 nitrogen 416 to 42 psig. A Parker pressure regulator 417 was used to control the water pressure upstream of a pair of membrane contactors 418, 419 to 40 psig. The membrane contactors 418, 419 were pHasor® II Membrane Contactors sold by Entegris, Inc. of Chaska, MN. The water from the pressurized water vessel 414 was sent through both membrane contactors 418, 419. A critical orifice 420 was used to
25 maintain the flow rate of the water to less than 1 slm (standard liter per minute). The actual water flow rate was calculated by measuring the amount of time needed to fill a 10ml beaker of water. The nitrogen 431 upstream of both membrane contactors 418, 419 was purified with an SS-500KF-I-4R purifier 421. An AP Tech pressure regulator 422 and a Sierra Instruments Inc. Mass Flow Meter (MFM) 423
30 were used to maintain and measure the flow rate of purified nitrogen through the lumens side of the membrane contactors 418, 419. An AP Tech pressure guage 424

- 10 -

was used to monitor the gas pressure upstream of the membrane contactors 418, 419. The membrane contactors 418, 419 were heated to 45°C by Watlow heater blankets (not shown). The vortex condensation trap 206 was used downstream of the membrane contactors 418, 419 to remove condensation from the nitrogen gas stream. A critical orifice 425 was used to maintain the flow rate of the water-saturated gas stream out of the condensation trap 206. The flow rate of humid gas out of the condensation trap 206 was measured by a rotameter. A gas filter 426, which was a Wafergard® II filter sold by Entegris, Inc. of Chaska, MN, was placed downstream of the condensation trap 206. The relative humidity and temperature downstream of the controlled humidity system of Fig. 4 was measured by a Vaisala Moisture Probe 427. A valve 428 and pressure gauge 429 were used to maintain and measure the pressure of the outlet gas stream. The outlet gas temperature was measured, and the corresponding relative humidity percentage values were recorded. A Data Logger program 430 was connected to the moisture probe 427 to record the moisture concentration data in an Excel spreadsheet. The system was also provided with vents 432, 433, drains 434, 435, and other valves, pressure gauges, regulators, etc. as will be recognized by those of skill in the art.

Table 1 shows the average relative humidity percentage values attained with the controlled humidity system of Fig. 4 using a vortex condensation trap 206 according to an embodiment of the invention. The table also lists the corresponding flow rates associated with the relative humidity percentage values, and the other operating conditions of the test.

Table 1: Relative Humidity Data using the Controlled Humidity System of Fig. 4

Gas Flow Rate (slm)	Average Relative Humidity (RH%)	Gas Outlet Temp (°C)	Heater Temp 1 (°C)	Heater Temp 2 (°C)	Gas Inlet Pressure (psig)	Gas Outlet Pressure (psig)	Pressure Drop Across CHS (psig)	Trap Flow Rate (slm)	Water Flow Rate (ml/hour)
60	87.9	25	45	45	18	7	11	3.4	545
120	68.3	22	45	45	30	7	23	3.6	571

As can be seen in Table 1, the relative humidity percentage decreased with increasing flow rates. This is believed to be because as gas flow rates increased,

- 11 -

larger volumes of dry gas diluted the moisture outputs of the membrane contactors 418, 419, thus causing a decrease in the relative humidity percentages. Higher gas flow rates also caused a decrease in the outlet temperature. The decrease in temperature is believed to be a result of the larger gas volume, which promoted the evaporation of gaseous water into the gas stream.

The results of Table 1 show an average relative humidity percentage value of 87.9% for a 60 slm flow rate, and of 68.3% for a 120 slm flow rate. The standard deviation was 1.017% for the 60 slm flow rate, and 1.95% for the 120 slm flow rate. The average relative humidity percentage values evidence an improved performance over the prior art condensation trap of Fig. 1. The vortex condensation trap 206 according to an embodiment of the invention produced measurable increases in the amount of water vapor in the gas stream, and in the stability of the humidity levels, while also avoiding flooding of the condensation trap. Since 85% relative humidity represents a desirable relative humidity percentage value, the vortex condensation trap 206 was closest to the desired relative humidity percentage value at a 60 slm flow rate. Also, the relative humidity percentage values were more stable at the lower 60 slm flow rate than at the higher 120 slm flow rate. The stability of the relative humidity percentage values may be affected by factors such as excess condensation and changes in pressure and temperature. To help attain improved and stable relative humidity percentage values, good tubing insulation should be used throughout the system, and consistent ambient temperature and system pressure should be maintained. The gas filter 426 and vortex condensation trap 206 should be placed as close to the membrane contactor heaters as possible, which may reduce the presence of cold regions in the system of Fig. 4 where condensation may occur. Also, controlling the outlet gas temperature of the system of Fig. 4 may help to attain more stable relative humidity percentage outputs. In accordance with an embodiment of the invention, the purge gas humidification system may be capable of operation at a purge gas flow rate of at least about 60 standard liters per minute and producing output humidified purge gas at a relative humidity percentage value of at least about 75%; or at least about 80%; or at least about 85%. Although an embodiment according to the invention is particularly advantageous for providing purge gas at high relative humidity levels, it may also be used at lower humidity

- 12 -

levels, and provide increased stability of humidity levels and reduction of excess condensation in such settings.

Fig. 5 schematically depicts a lithographic projection apparatus 1 in which a controlled humidity source using a vortex condensation trap according to an embodiment of the present invention may be used. The apparatus 1 includes a base plate BP. The apparatus may also include a radiation source LA (e.g., EITV radiation). A first object (mask) table MT is provided with a mask holder configured to hold a mask MA (e.g., a reticle), and is connected to a first positioning device PM that accurately positions the mask with respect to a projection system or lens PL. A second object (substrate) table WT is provided with a substrate holder configured to hold a substrate W (e.g., a resist-coated silicon wafer), and is connected to a second positioning device PW that accurately positions the substrate with respect to the projection system PL. The projection system or lens PL (e.g. a mirror group) is configured to image an irradiated portion of the mask MA onto a target portion C (e.g., comprising one or more dies) of the substrate W.

The source LA (e.g., a discharge or laser-produced plasma source) produces radiation. This radiation is fed into an illumination system (illuminator) IL, either directly or after having traversed a conditioning device, such as a beam expander EX, for example. The illuminator IL may include an adjusting device AM that sets the outer and/or inner radial extent (commonly referred to as σ -outer and σ -inner, respectively) of the intensity distribution in the beam. In addition, it will generally comprise various other components, such as an integrator IN and a condenser CO. In this way, the beam PB impinging on the mask MA has a desired uniformity and intensity distribution in its cross-section.

The beam PB subsequently intercepts the mask MA, which is held on a mask table MT. Having traversed the mask MA, the beam PB passes through the lens PL, which focuses the beam PB onto a target portion C of the substrate W. With the aid of the second positioning device PW and interferometer IF, the substrate table WT can be moved accurately, e.g., so as to position different target portions C in the path of the beam PB. Similarly, the first positioning device PM can be used to accurately position the mask MA with respect to the path of the beam PB, e.g. after mechanical retrieval of the mask MA from a mask library, or during a scan. In general,

- 13 -

movement of the object tables MT, WT will be realized with the aid of a long-stroke module (coarse positioning) and a short-stroke module (fine positioning), which are not explicitly depicted in FIG. 1. However, in the case of a wafer stepper (as opposed to a step and scan apparatus) the mask table MT may just be connected to a short stroke actuator, or may be fixed. The mask MA and the substrate W may be aligned using mask alignment marks M_1 and M_2 and substrate alignment marks P_1 and P_2 .

Fig. 6 shows the projection system PL and a radiation system 2 that can be used in the lithographic projection apparatus 1 of Fig. 5. The radiation system 2 includes an illumination optics unit 4. The radiation system 2 can also comprise a source-collector module or radiation unit 3. The radiation unit 3 is provided with a radiation source LA that can be formed by a discharge plasma. The radiation source LA may employ a gas or vapor, such as Xe gas or Li vapor in which a very hot plasma may be created to emit radiation in the EUV range of the electromagnetic spectrum. The very hot plasma is created by causing a partially ionized plasma of an electrical discharge to collapse onto the optical axis O. Partial pressures of 0.1 mbar of Xe, Li vapor or any other suitable gas or vapor may be required for efficient generation of the radiation. The radiation emitted by radiation source LA is passed from the source chamber 7 into collector chamber 8 via a gas barrier structure or "foil trap" 9. The gas barrier structure 9 includes a channel structure such as, for instance, described in detail in EP 1 233 468 A and EP 1 057 079 A.

The collector chamber 8 comprises a radiation collector 10, which can be a grazing incidence collector. Radiation passed by collector 10 is reflected off a grating spectral filter 11 to be focused in a virtual source point 12 at an aperture in the collector chamber 8. From chamber 8, the projection beam 16 is reflected in illumination optics unit 4 via normal incidence reflectors 13 and 14 onto a reticle or mask positioned on reticle or mask table MT. A patterned beam 17 is formed, which is imaged in projection system PL via reflective elements 18 and 19 onto a wafer stage or substrate table WT. More elements than shown may generally be present in illumination optics unit 4 and projection system PL.

As is shown in Fig. 6, the lithographic projection apparatus 1 includes a purge gas supply system 636. Purge gas outlets 637-640 of the purge gas supply

- 14 -

system 636 are positioned in the projection system PL and the radiation system 2 near the reflectors 13 and 14 and the reflective elements 18 and 19, as is shown in Fig. 6. However, if so desired, other parts of the apparatus may likewise be provided with a purge gas supply system. For example, a reticle and one or more sensors of the lithographic projection apparatus may be provided with a purge gas supply system.

In Figs. 5 and 6, the purge gas supply system 636 is positioned inside the lithographic projection apparatus 1. The purge gas supply system 636 can be controlled in any manner suitable for the specific implementation using any device outside the apparatus 1. However, it is likewise possible to position at least some parts of the purge gas supply system 636 outside the lithographic projection apparatus 1, for example the purge gas mixture generator 641.

Fig. 7 shows an exemplary embodiment of a purge gas supply system 636, in which a vortex condensation trap according to an embodiment of the invention may be used. A purge gas inlet 742 is connected to a purge gas supply apparatus (not shown) that supplies a dry gas that is substantially without moisture, for example, a pressurized gas supply circuit, a cylinder with compressed dry air or otherwise. The dry gas is fed through the purge gas mixture generator 641. In the purge gas mixture generator 641 the dry gas is purified further, as explained below. Further, the purge gas mixture generator 641 includes a moisturizer 743 which adds moisture to the dry gas for the purge gas outlet 637. The other purge gas outlets 638 and 639 are not connected to the moisturizer 743. Thus, at the purge gas outlet 637, a purge gas mixture including the purge gas and moisture is presented, whereas at the other purge gas outlets 638 and 639 only the dry purge gas is presented. Thereby the purge gas mixture may be provided only near surfaces provided with chemicals that require a moisture, such as the wafer table WT, whereas other parts of the lithographic projection apparatus 1 can be provided with a dry purge gas, i.e., without moisture. Nevertheless, the invention is not limited to use in purge gas mixture generators where only one outlet of the generator supplies the purge gas mixture.

Furthermore, because the moisture is added to a purge gas, properties of the purge gas mixture, such as the relative humidity or purity of the moisture, can be

- 15 -

controlled with good accuracy. Also, because of the moisturizer the system is flexible, as the moisturizer allows the amount of moisture present in the purge gas mixture to easily be adjusted by adding more or less moisture to the purge gas.

The purge gas mixture generator 641 includes, in a flow direction: a purifier apparatus 744, a flow meter 745, a valve 746, a reducer 747, a heat exchanger 748 and the moisturizer 743:

In accordance with an embodiment of the invention, the moisturizer 743 may be a pHasor® II Membrane Contactor sold by Entegris, Inc. of Chaska, MN, or another membrane contactor. The purge gas supply system 636 may further include a vortex condensation trap in accordance with an embodiment of the invention, such as vortex condensation trap 206 of Figs. 2 and 3A-3C. The vortex condensation trap may be placed, for example, downstream of moisturizer 743 and upstream of the purge gas outlet 637; or outside of purge gas supply system 636, e.g., downstream of purge gas outlet 637 and upstream of a system to which the purge gas is being supplied. In addition to being used in the purge gas supply system 636 of the embodiment of Fig. 7, a vortex condensation trap according to an embodiment of the invention may also be used, for example, in a controlled humidity source similar to that of Fig. 4, or in another source of humidified purge gas, as will be appreciated by those of skill in the art. Further, a vortex condensation trap according to an embodiment of the invention may be used with a variety of different moisturizers, including membrane contactors, bubblers, and other moisturizers.

In the embodiment of Fig. 7, compressed dry air (CDA) from a CDA source (not shown) is supplied to the purifier apparatus 744 via the purge gas inlet 742. The CDA is purified by the purifier 744. The purifier 744 includes two parallel flow branches 744A and 744B each including, in the flow direction: an automatic valve 7441 or 7442 and a regenerable purifier device 7443 or 7444. The regenerable purifier devices 7443 and 7444 are each provided with a heating element to heat and thereby regenerate the respective purifier devices 7443 and 7444. The flow branches are connected downstream of the purifier devices 7443 and 7444 to a shut-off valve 7445 that is controlled by a purity sensor 7446.

- 16 -

The heat exchanger 748 is connected via restrictions 749-751 to the purge gas outlets 637-639. The restrictions 749-751 limit the gas flow, such that at each of the purge gas outlets 637-639 a desired, fixed purge gas flow and pressure is obtained. A suitable value for the purge gas pressure at the purge gas outlets is, for example, 100 mbar. It is likewise possible to use adjustable restrictions to provide an adjustable gas flow at each of the purge gas outlets 637-639.

The moisturizer 743 is connected downstream from the heat exchanger between the restriction 749 and the purge gas outlet 637. The purge gas outlet 637 is provided in the example of Figs. 5 and 6 near the wafer table WT. The moisturizer 743 adds moisture to the purified CDA and thus provides a purge gas mixture to the outlet 637. In this example, only at a single outlet a purge gas mixture is discharged. However, it is likewise possible to discharge a purge gas mixture to two or more purge gas outlets, for example by connecting a multiple of purge gas outlets to separate moisturizers or connecting two or more outlets to the same moisturizer. It is likewise possible to provide a moisturizer at a different position in the purge gas mixture generator than is shown in Fig. 7. For example, the moisturizer 743 may be placed between the purge gas mixture generator 641 and the valve 749 instead of between the valve 749 and the purge gas outlet 637. The moisturizer 743 operates as a restriction as well and if so desired, the restriction 637 connected to the moisturizer 743 may be omitted.

Preferred moisturizers 743 for use in accordance with an embodiment of the invention include a first region containing a purge gas flow and a second region containing water where the first and second regions are separated by a gas-permeable membrane that is substantially resistant to liquid intrusion. Suitable materials for the membranes include thermoplastic polymers such as poly(tetrafluoroethylene-co-perfluoro-3,6-dioxo-4-methyl-7-octene sulfonic acid) and perfluorinated polymers such as polytetrafluoroethylene. Non-wettable polymers, such as the perfluorinated polymers, are particularly preferred, especially polymers that are suitable for use with high pressure fluids and are substantially free of inorganic oxides (e.g., SO_x and NO_x , where x is an integer from 1-3). The membranes can be a sheet, which can be folded or pleated, or can be joined at opposite sides to form a hollow fiber. It is only essential that the membrane, in

- 17 -

combination with any sealants or adhesives used to join the membrane to a housing, prevents liquid from permeating into a purge gas under normal operating conditions (e.g., pressures of 30 psig or less). The membrane is preferably configured to maximize the surface area of the membrane contacting the purge gas and the water and minimize the volume of the membrane. A moisturizer can contain more than one membrane per device, as described below.

Moisturizers having hollow fiber membranes typically include:

- a) a bundle of a plurality of gas-permeable hollow fiber membranes having a first end and a second end, where the membranes have an outer surface and an inner surface, with the inner surface encompassing one of the first and second regions;
- b) each end of the bundle potted with a liquid tight seal forming an end structure with a surrounding housing where the fiber ends are open to fluid flow;
- c) the housing having an inner wall and an outer wall, where the inner wall defines the other of the first and second regions between the inner wall and the hollow fiber membranes;
- d) the housing having a purge gas inlet connected to the purge gas source and a purge gas mixture outlet; and
- e) the housing having a water inlet connected to the water source and a water outlet, wherein either the purge gas inlet is connected to the first end of the bundle and the purge gas mixture outlet is connected to the second end of the bundle or the water inlet is connected to the first end of the bundle and the water outlet is connected to the second end of the bundle.

Devices having hollow fiber membranes that are generally suitable for use as moisturizers are typically referred to as membrane contactors, and are described in U.S. Patent Nos. 6,149,817, 6,235,641, 6,309,550, 6,402,818, 6,474,628, 6,616,841, 6,669,177 and 6,702,941, the entire contents of which are incorporated herein by reference. Although many of the membrane contactors are described in the preceding patents as being useful for adding gas to or removing gas from a liquid (e.g., water), membrane contactors can generally be operated such that water vapor

- 18 -

is added to a purge gas flow. Particular examples of membrane contactors suitable for use as moisturizers include the Infuzor[®] membrane contactor module marketed by Pall Corporation, Liqui-Cel[®] marketed by Membrana-Charlotte and Nafion[®] Membrane fuel cell humidifiers marketed by PermaPure LLC.

5 A diagram of a particularly preferred moisturizer that may be used with a vortex condensation trap according to an embodiment of the invention is shown in Fig. 8, the commercial embodiment of which is the pHasor[®] II Membrane Contactor, which is marketed by Entegris, Inc. of Chaska, MN. As illustrated in Fig. 8, fluid 852 enters the moisturizer 853 through connector 859 and fiber lumens 10 854, traverses the interior of the moisturizer 853 while in the lumens 854, where it is separated from fluid 855 by the membrane, and exits the contactor 853 through the fiber lumens at connection 856. Fluid 855 enters the housing through connection 857 and substantially fills the space between the inner wall of the housing and the outer diameters of the fibers, and exits through connector 858. One 15 of the purge gas and the water is fluid 852 and the other is fluid 855. Preferably, the water is fluid 855.

The gas-permeable hollow fiber membranes used in the preferred moisturizer of the invention are typically one of the following:

- 20 a) hollow fiber membranes having a porous skinned inner surface, a porous outer surface and a porous support structure between;
- b) hollow fiber membranes having a non-porous skinned inner surface, a porous outer surface and a porous support structure between;
- c) hollow fiber membranes having a porous skinned outer surface, a porous inner surface and a porous support structure between; or
- 25 d) hollow fiber membranes having a non-porous skinned outer surface, a porous inner surface and a porous support structure between.

These hollow fiber membranes preferably have an outer diameter of about 350 microns to about 1450 microns.

30 When these hollow fiber membranes are hollow fiber membranes having a porous skinned inner surface, a porous outer surface and a porous support structure between or hollow fiber membranes having a porous skinned outer surface, a porous inner surface and a porous support structure between, the porous skinned surface

- 19 -

pores are preferably from about 0.001 microns to about 0.005 microns in diameter. The pores in the skinned surface preferably face the liquid flow.

Suitable materials for these hollow fiber membranes include perfluorinated thermoplastic polymers such as poly(tetrafluoroethylene-co-perfluoro(alkylvinylether)) (poly(PTFE-CO-PFVAE)), poly(tetrafluoroethylene-co-hexafluoropropylene) (FEP) or a blend thereof, because these polymers are not adversely affected by severe conditions of use. PFA Teflon[®] is an example of a poly(PTFE-CO-PFVAE) in which the alkyl is primarily or completely the propyl group. FEP Teflon[®] is an example of poly(FEP). Both are manufactured by DuPont. Neoflon[™] PFA (Daikin Industries) is a polymer similar to DuPont's PFA Teflon[®]. A poly(PTFE-CO-PFVAE) in which the alkyl group is primarily methyl is described in U.S. Patent No. 5,463,006, the contents of which are incorporated herein by reference in their entirety. A preferred polymer is Hyflon[®] poly(PTFE-CO-PFVAE) 620, obtainable from Ausimont USA, Inc., Thorofare, N.J. Methods of forming these polymers into hollow fiber membranes are disclosed in U.S. Patent Nos. 6,582,496 and 4,902,456, the contents of which are incorporated herein by reference in their entirety.

Purge gas mixture supply systems are typically capable of operation at a purge gas flow rate of at least about 30 standard liters per minute and a temperature of at least about 90°C. When heated water is used in the moisturizer, the water temperature is preferably at least 30°C, namely at least about 35°C, such as at least about 50°C or at least about 60°C. Flow rates of purge gas through the moisturizer are typically at least about 20 standard liters per minute (slm), for example, at least about 60 slm.

Purge gas mixtures (humidified purge gas) exiting a preferred moisturizer of the invention preferably can have a relative humidity of at least about 20%. Higher relative humidity values of at least about 50% or about 100% (to produce a substantially saturated purge gas) are possible, depending upon the conditions under which the moisturizer is operated. For example, higher stabilized relative humidity values are reached by lengthening the time a purge gas resides in the moisturizer (e.g., by reducing the flow rate or increasing the size of the moisturizer) or heating the moisturizer or at least the water in the moisturizer. The gas pressure and flow of

- 20 -

water across a membrane can be further controlled by a mass flow controller. In particular, lowering the pressure of the purge gas results in increased humidification of the purge gas. When the purge gas pressure is decreased, the need to heat the water to obtain a high relative humidity is lessened.

5 The moisturizer device of Fig. 8 can be provided with a control device via which the amount of moisture in the purge gas mixture can be controlled. The control device is connected with a moisture control contact to a control valve via which the flow rate of unhumidified purge gas supplied (e.g., direct from the purge gas source) to a mixing chamber with humidified purge gas exiting the moisturizer
10 of Fig. 8 can be controlled.

Purge gas mixture generators are advantageously heated for a sufficient length of time at a temperature sufficient to substantially remove compounds that volatilize at temperatures of about 100°C or less. This allows their use in applications where essentially contaminant-free gas is required. For purposes of the
15 present invention, a purge gas is defined as a gas or a mixture of gas having contaminant levels of no greater than 1 ppb. Purge gases include inert gases such as nitrogen and argon, along with oxygen-containing gases such as compressed dry air and clean dry gas. An appropriate purge gas is determined relative to the intended application, such that non-inert gases such as oxygen are not contaminants in certain
20 uses but are considered contaminants in other uses. Preferably, the purge gas mixture generators (and moisturizers) do not contribute contaminants to a purge gas. For example, a purge gas containing no greater than about 1 ppb (or about 100 parts per trillion (ppt)) of contaminants exits the moisturizer as a humidified purge gas containing no greater than about 1 ppb (or 100 ppt) of contaminants. Particular
25 moisturizers are capable of humidifying a purge gas such that contaminant levels remain less than 1 ppt.

Water used in humidification water sources are preferably UHP water (e.g., Millipore MilliQ® water) that is distilled and filtered.

Fig. 9 is an outside view of a controlled humidity source using a vortex
30 condensation trap according to an embodiment of the invention. In a similar fashion to the embodiment of Fig. 4, Fig. 9 uses dual moisturizers 418, 419 with heaters, a vortex condensation trap 206, and a gas filter 426.

- 21 -

5 An embodiment according to the present invention provides a vortex condensation trap that may be used in apparatuses and methods for humidifying a purge gas. Although such humidified purge gases are particularly beneficial in lithographic systems, the use of an embodiment according to the invention is not limited to such systems. Introducing water into a system using a humidification source with a vortex condensation trap according to an embodiment of the invention may provide improved relative humidity percentage values, relative humidity stability, and the removal of excess water condensation, for use in a variety of different possible applications.

10 While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.

- 22 -

CLAIMS

What is claimed is:

1. A purge gas humidification system, the system comprising:
a moisturizer configured to add moisture to a purge gas; and
5 a condensation trap comprising an inlet configured to receive humidified purge gas from the moisturizer, a water drain configured to drain excess condensed water from the condensation trap, and an outlet configured to output humidified purge gas from the condensation trap;
10 wherein the condensation trap is configured to induce a substantially vortex flow pattern in the humidified purge gas received from the moisturizer.
2. The purge gas humidification system according to Claim 1, wherein
15 an outlet tube of the condensation trap is configured to support a fluid dynamic path around its outside surface such that the substantially vortex flow pattern is induced.
3. The purge gas humidification system according to Claim 2, wherein a
20 flow volume of the outlet tube is larger than a flow volume of the inlet of the condensation trap.
4. The purge gas humidification system according to Claim 2, wherein
25 the inlet of the condensation trap is tangentially-offset from a radial axis of the condensation trap.
5. The purge gas humidification system according to Claim 1, wherein
30 an inlet tube of the condensation trap enters the condensation trap perpendicular to a longitudinal axis of the condensation trap.

- 23 -

6. The purge gas humidification system according to Claim 5, wherein an outlet tube of the condensation trap is parallel to the longitudinal axis of the condensation trap.
- 5 7. The purge gas humidification system according to Claim 6, wherein a central axis of the water drain of the condensation trap is parallel to the longitudinal axis of the condensation trap.
- 10 8. The purge gas humidification system according to Claim 1, wherein the moisturizer comprises a first region containing a purge gas flow and a second region containing water wherein the first and second regions are separated by a gas-permeable membrane that is substantially resistant to liquid intrusion.
- 15 9. The purge gas humidification system according to Claim 8, wherein the membrane comprises a perfluorinated polymer.
- 20 10. The purge gas humidification system according to Claim 9, wherein the moisturizer comprises:
 - a) a bundle of a plurality of gas-permeable hollow fiber membranes having a first end and a second end, said membranes having an outer surface and an inner surface, said inner surface comprising one of the first and second regions;
 - 25 b) each end of said bundle potted with a liquid tight seal forming an end structure with a surrounding housing wherein the fiber ends are open to fluid flow;
 - c) said housing having an inner wall and an outer wall, wherein the inner wall defines the other of the first and second regions between the inner wall and the hollow fiber membranes;
 - 30 d) said housing having a purge gas inlet connected to a purge gas source and a purge gas mixture outlet; and

- 24 -

- 5 e) said housing having a water inlet connected to a water source and a water outlet, wherein either the purge gas inlet is connected to the first end of the bundle and the purge gas mixture outlet is connected to the second end of the bundle or the water inlet is connected to the first end of the bundle and the water outlet is connected to the second end of the bundle.
- 10 11. The purge gas humidification system according to Claim 1, further comprising a heating device configured to heat the moisturizer.
- 15 12. The purge gas humidification system according to Claim 1, wherein the purge gas humidification system is capable of operation at a purge gas flow rate of at least about 60 standard liters per minute and producing output humidified purge gas at a relative humidity percentage value of at least about 75%.
- 20 13. A method of humidifying a purge gas, comprising:
passing a purge gas through a moisturizer for a period sufficient to humidify the purge gas;
passing humidified purge gas output from the moisturizer into a condensation trap;
flowing the humidified purge gas through the condensation trap in a substantially vortex flow pattern;
draining excess condensed water from the condensation trap;
- 25 and
outputting humidified purge gas from the condensation trap.
- 30 14. The method according to Claim 13, further comprising flowing the humidified purge gas in a fluid dynamic path around an outside surface of an outlet tube of the condensation trap to induce the substantially vortex flow pattern.

- 25 -

15. The method according to Claim 14, wherein a flow volume of the outlet tube is larger than a flow volume of an inlet of the condensation trap.
- 5 16. The method according to Claim 13, further comprising passing the humidified purge gas into the condensation trap through an inlet that is tangentially-offset from a radial axis of the condensation trap.
- 10 17. The method according to Claim 13, further comprising passing the humidified purge gas into the condensation trap through an inlet that is perpendicular to a longitudinal axis of the condensation trap.
- 15 18. The method according to Claim 17, further comprising outputting humidified purge gas from the condensation trap through an outlet tube that is perpendicular to the longitudinal axis of the condensation trap.
- 20 19. The method according to Claim 18, further comprising draining the excess condensed water from the condensation trap through a water drain having a central axis that is parallel to the longitudinal axis of the condensation trap.
- 25 20. A lithographic projection apparatus, comprising:
an illuminator configured to provide a projection beam of radiation;
a support structure configured to support a patterning device, the patterning device configured to pattern the projection beam according to a desired pattern;
a substrate table configured to hold a substrate;
30 a projection system configured to project the patterned beam onto a target portion of the substrate; and

- 26 -

at least one purge gas supply system configured to provide a purge gas to at least part of the lithographic projection apparatus, the at least one purge gas supply system comprising:

- 5 a purge gas mixture generator comprising a
moisturizer configured to add moisture to a purge gas, and a
condensation trap comprising an inlet configured to receive
humidified purge gas from the moisturizer, a water drain
configured to drain excess condensed water from the
condensation trap, and an outlet configured to output
10 humidified purge gas from the condensation trap, wherein the
condensation trap is configured to induce a substantially
vortex flow pattern in the humidified purge gas received from
the moisturizer; and
15 a purge gas mixture outlet connected to the purge gas
mixture generator configured to supply the purge gas mixture
to the at least part of the lithographic projection apparatus.

21. A method for providing a purge gas to at least part of a
lithographic projection apparatus, the lithographic projection
20 apparatus comprising:
an illuminator configured to provide a projection beam of
radiation;
a support configured to support a patterning device, the
patterning device configured to pattern the projection beam according
25 to a desired pattern;
a substrate table configured to hold a substrate; and
a projection system configured to project the patterned beam
onto a target portion of the substrate;
the method comprising:
30 generating a purge gas mixture that comprises at least
one purge gas and moisture by adding moisture to a purge gas
with a moisturizer and removing excess condensation from

- 27 -

generating a purge gas mixture that comprises at least one purge gas and moisture by adding moisture to a purge gas with a moisturizer and removing excess condensation from the purge gas with a condensation trap, wherein the

5 condensation trap comprises an inlet configured to receive humidified purge gas from the moisturizer, a water drain configured to drain excess condensed water from the condensation trap, and an outlet configured to output humidified purge gas from the condensation trap, wherein the

10 condensation trap is configured to induce a substantially vortex flow pattern in the humidified purge gas received from the moisturizer, and

supplying the purge gas mixture to at least a part of the lithographic projection apparatus.

1/8

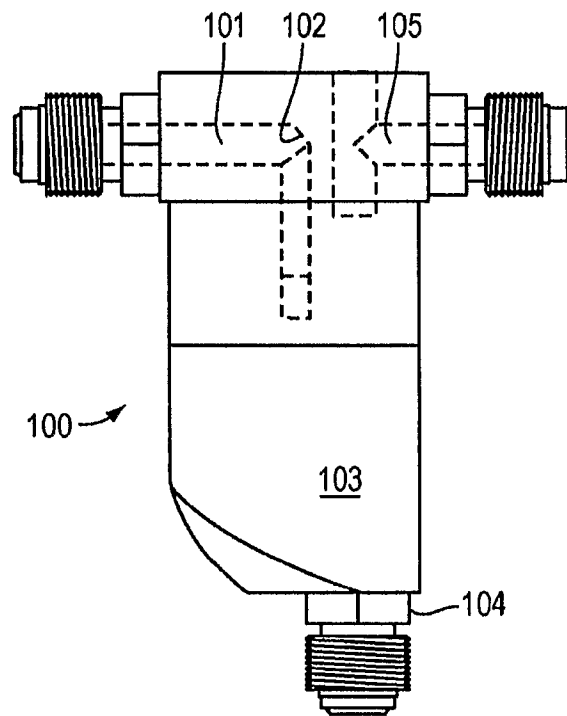


FIG. 1
PRIOR ART

2/8

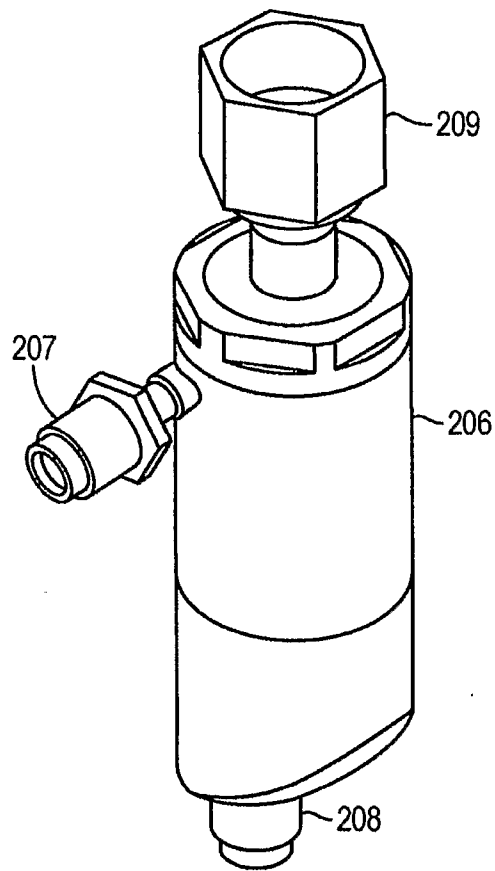


FIG. 2

3/8

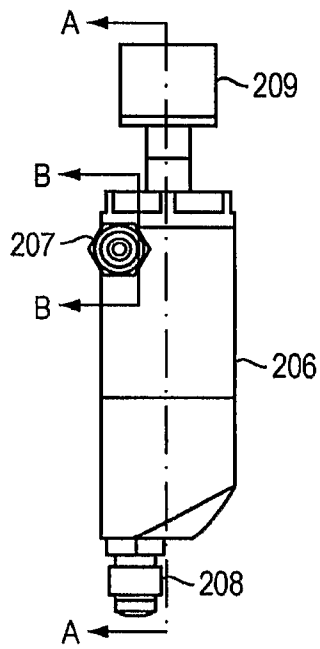


FIG. 3A

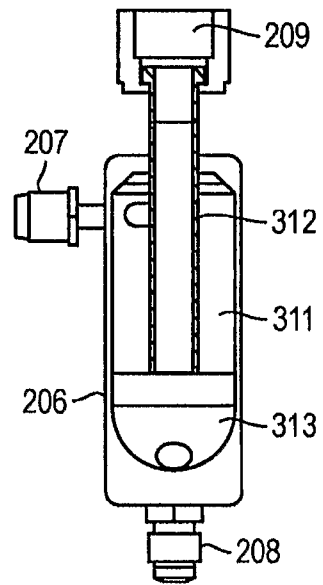


FIG. 3B

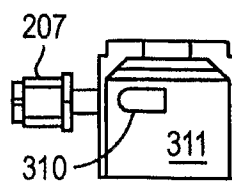


FIG. 3C

4/8

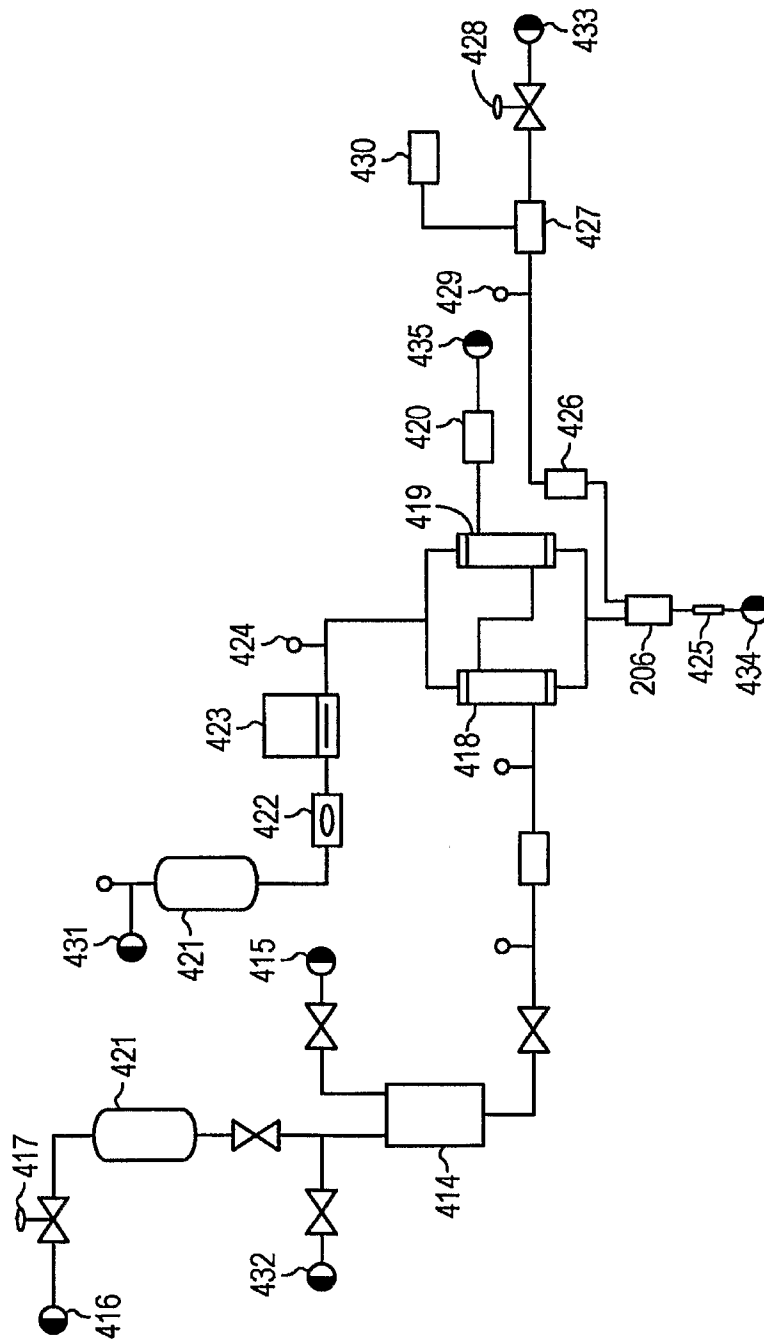


FIG. 4

5/8

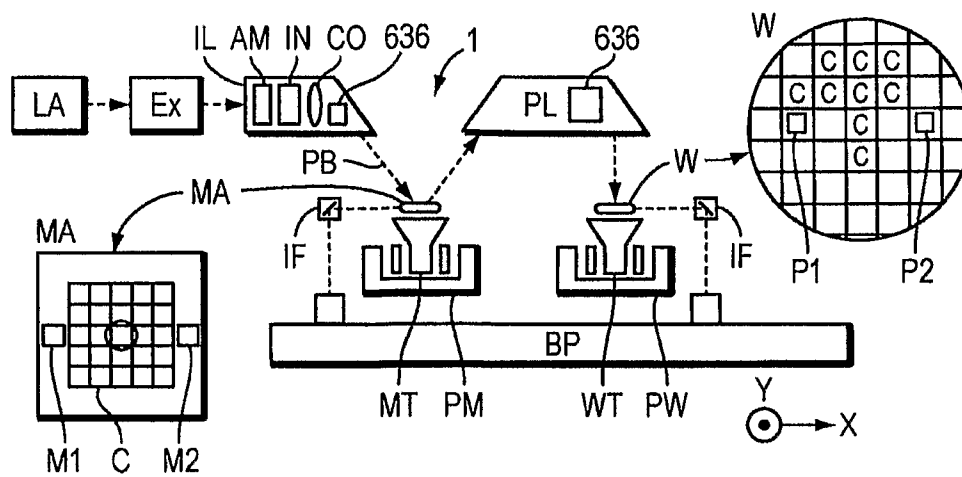


FIG. 5

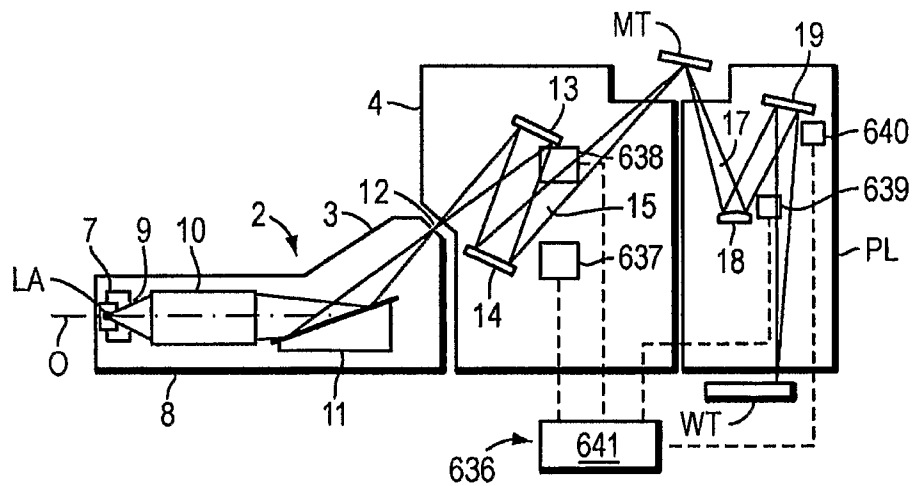


FIG. 6

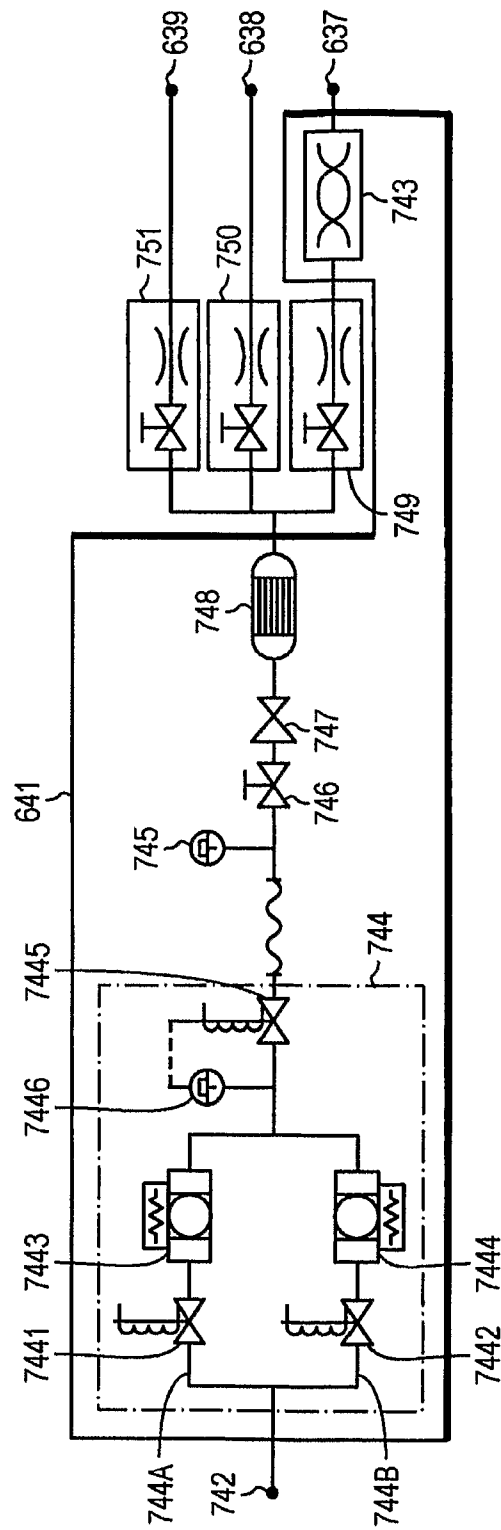


FIG. 7

7/8

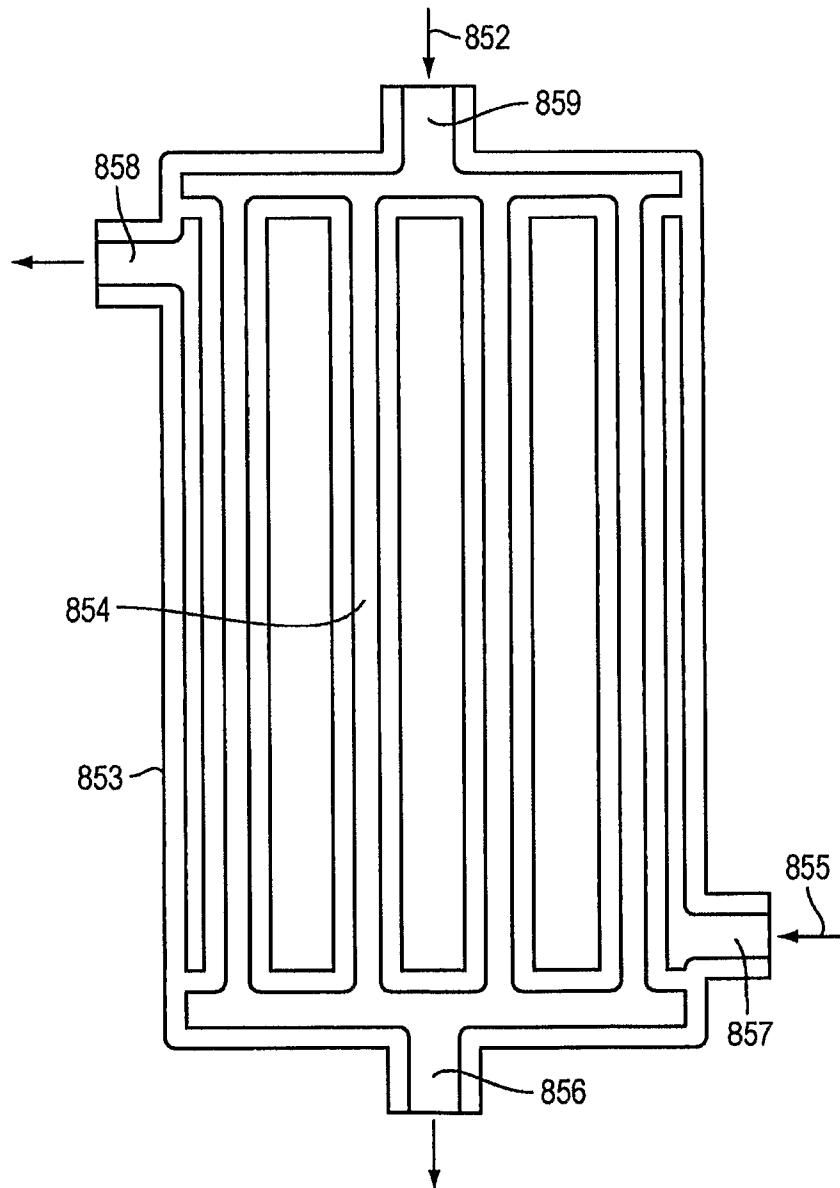


FIG. 8

8/8

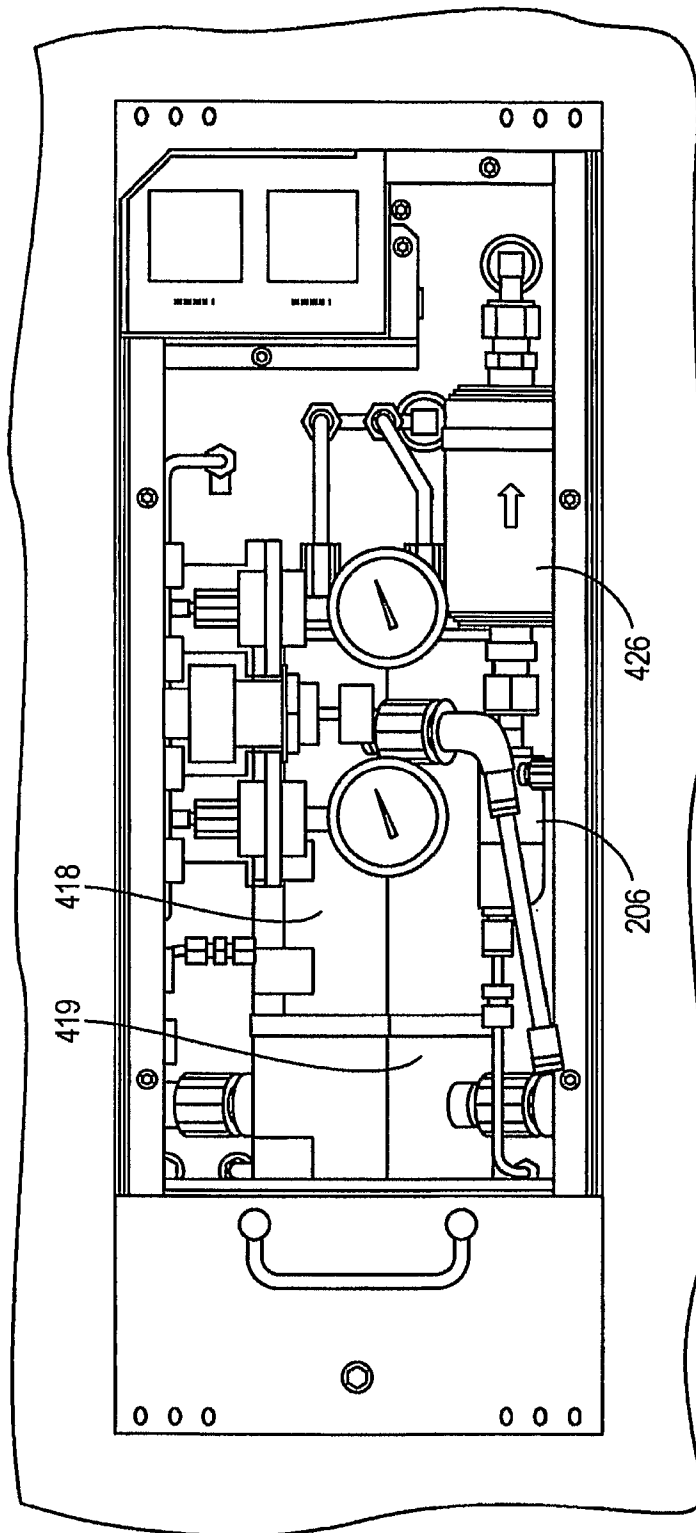


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/018158

A. CLASSIFICATION OF SUBJECT MATTER

INV. G03F7/20

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)
G03F H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1 455 149 A (ENTOLETER) 10 November 1976 (1976-11-10)	1, 13
Y	page 1, line 19 figures 1, 2 page 2, lines 68-75 page 3, lines 20-23 page 4, lines 13-25 -----	20, 21
Y	DE 32 14 325 A1 (JENOPTIK JENA GMBH [DD]) 27 January 1983 (1983-01-27) claim 4 figure 2 page 9, lines 16, 19, 27-35 -----	20, 21
A	US 6 582 496 B1 (CHENG KWOK-SHUN [US] ET AL) 24 June 2003 (2003-06-24) abstract figure 1 claim 1 -----	1-21

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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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.

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Date of the actual completion of the international search

12 December 2007

Date of mailing of the international search report

04/01/2008

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2007/018158

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