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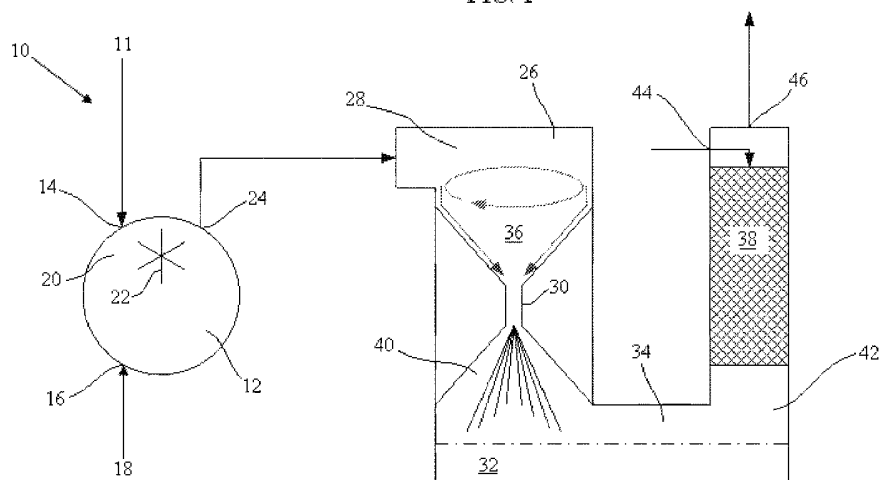
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(54) Title of the Invention: **Abatement system**
Abstract Title: **Abatement system**

(57) An abatement system 10 comprises a liquid ring pump 12 for compressing and pre-scrubbing gas evacuated from a processing chamber. The liquid ring pump has a gas inlet 14 for receiving evacuated gas, such as gas evacuated from a dry pumping arrangement. A liquid inlet 16 is provided for receiving liquid for generating a liquid ring in a stator 20 of the pump when a rotor 22 rotates in the stator. A gas and liquid outlet 24 is provided for exhausting gas and liquid in a gas/liquid ratio. A venturi scrubber 26 has an inlet for receiving the gas and liquid mixture from the liquid ring pump and a nozzle 30 for providing mixing of the gas with the liquid. A liquid sump 32 is provided for collecting liquid conveyed through the nozzle and a gas outlet is provided for exhausting gas from the venturi scrubber. The liquid ring pump is configured to exhaust gas and liquid at a pressure which drives the gas and liquid through the venturi scrubber. The abatement system provides for efficient scrubbing of water soluble and hydrolysable gases and an efficient means of capturing sub-micron particles.

FIG. 1



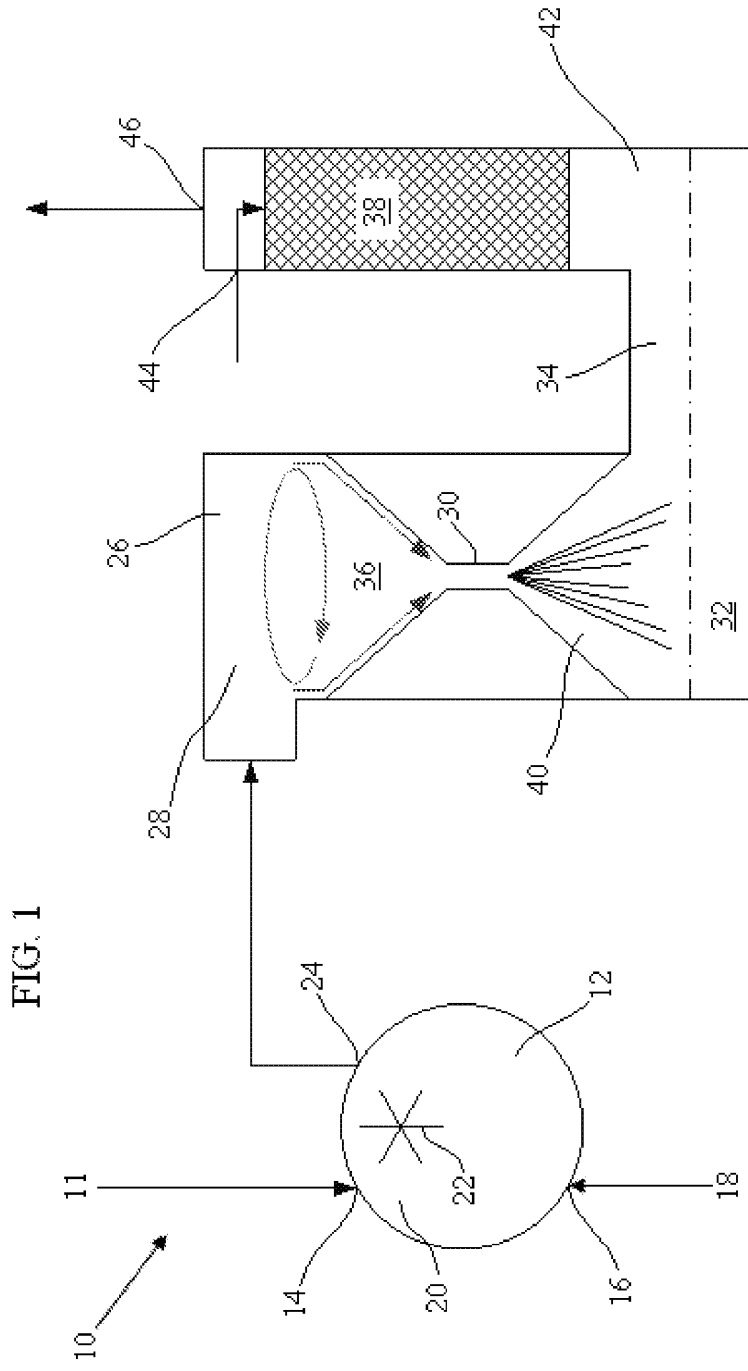


FIG. 1

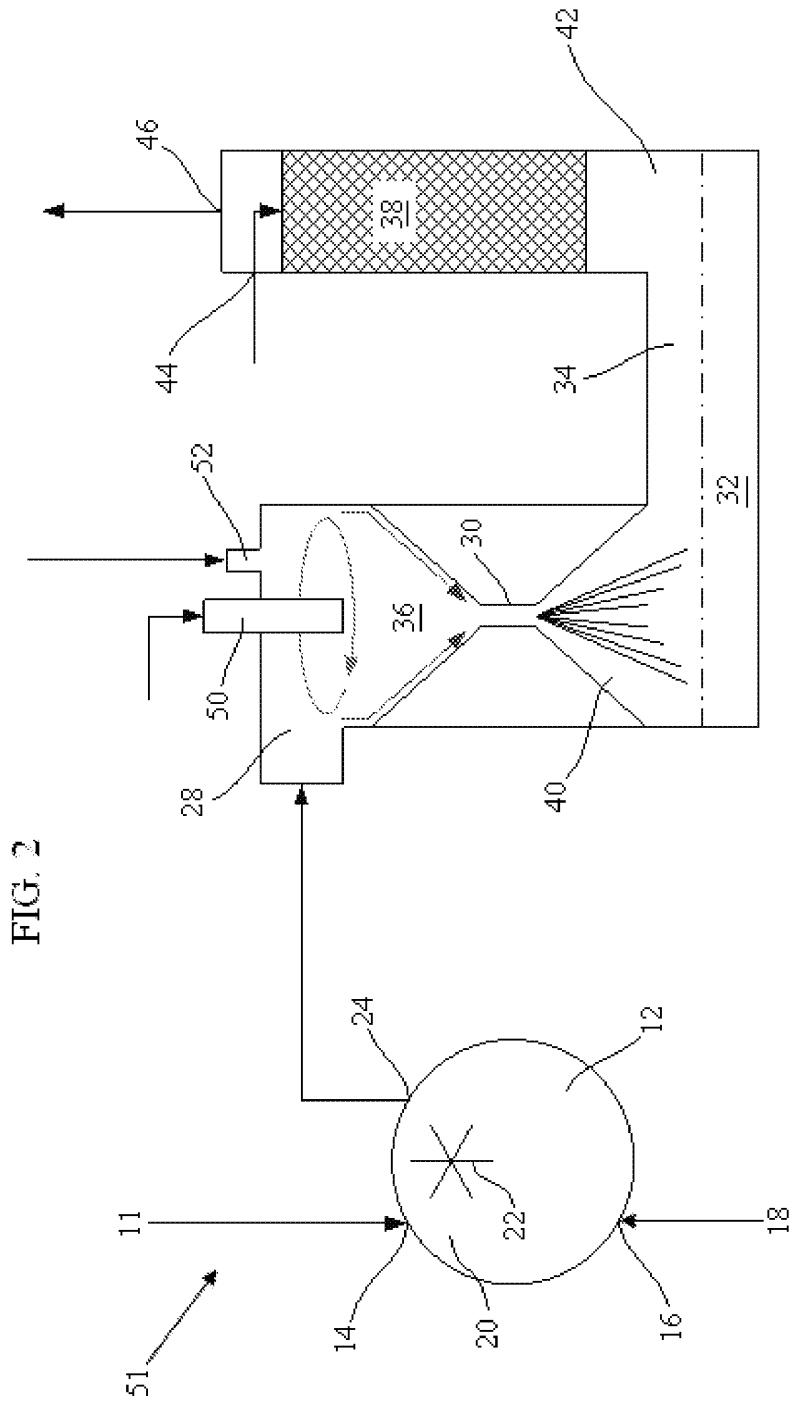


FIG. 2

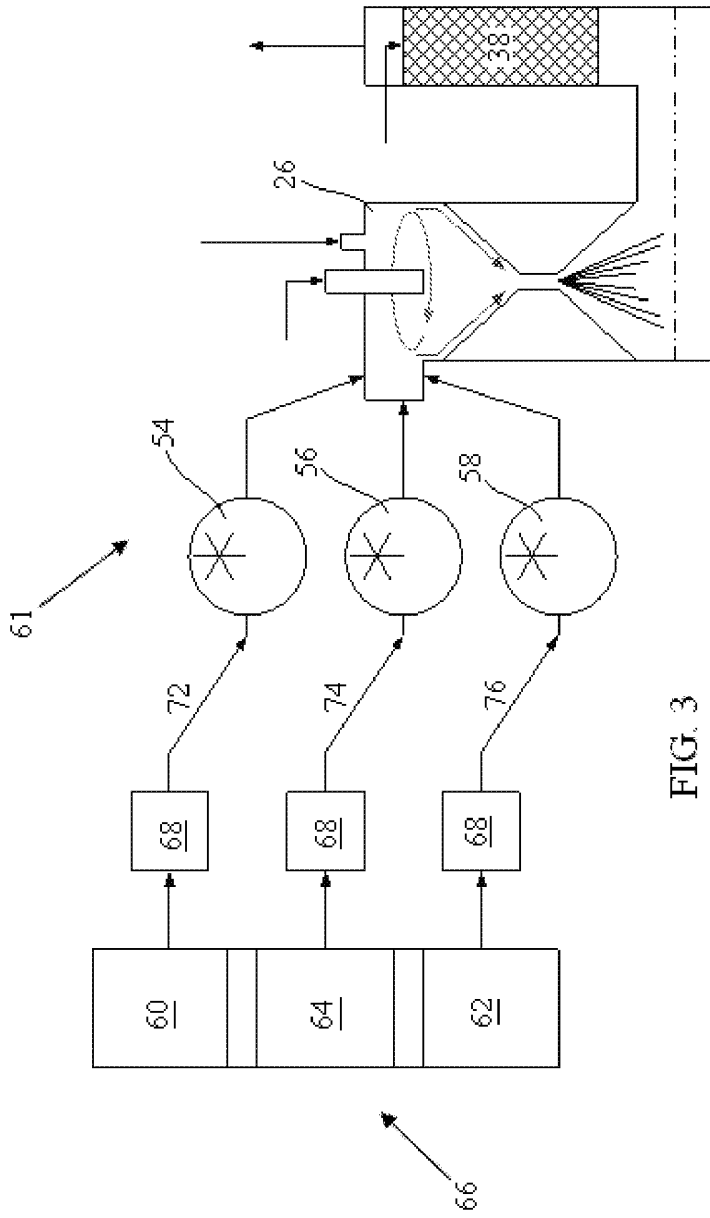


FIG. 3

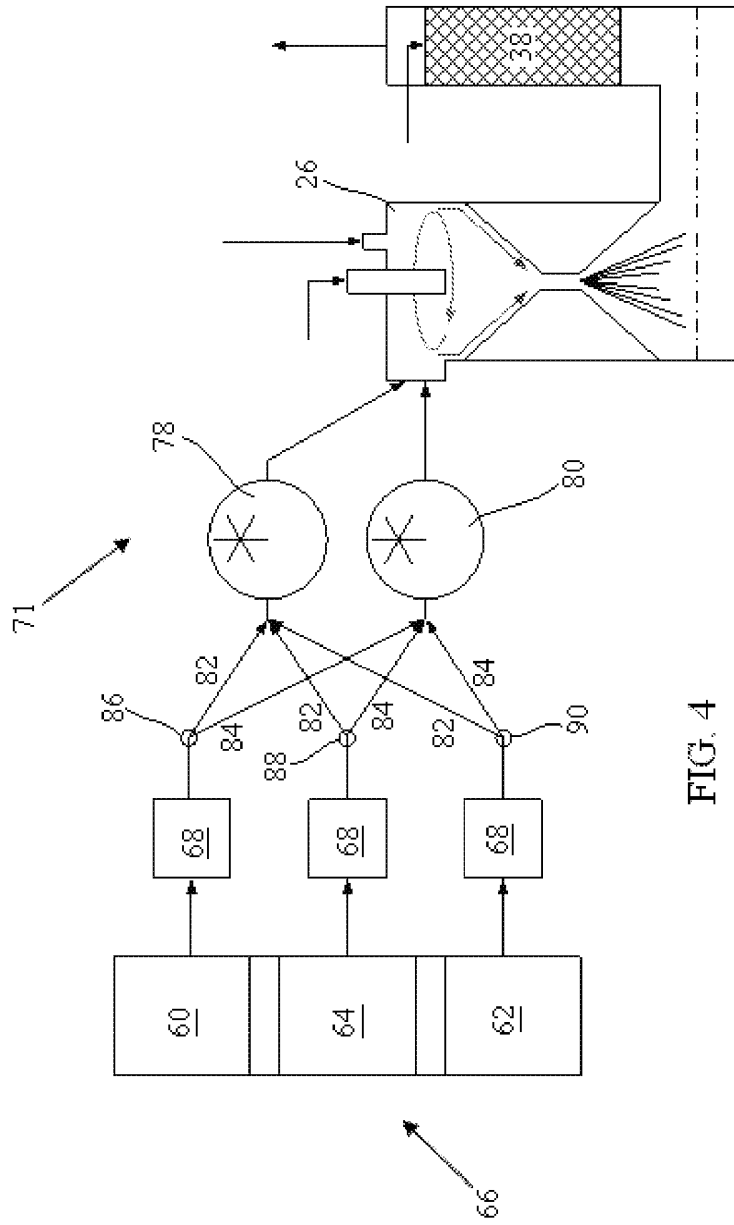


FIG. 4

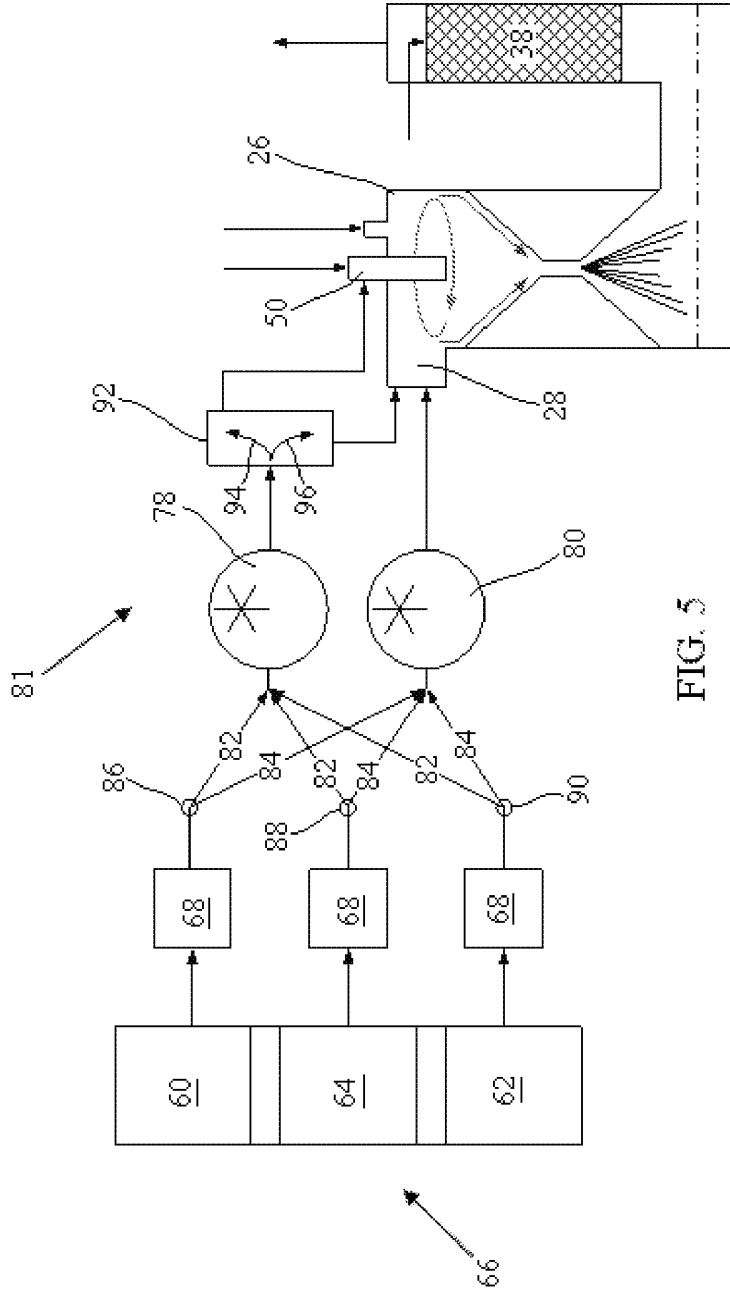


FIG. 5

ABATEMENT SYSTEM

The present invention relates to an abatement system for abating effluent gas evacuated from a processing chamber.

5 Abatement systems for abating effluent gas evacuated from a processing chamber are known and may be configured for treating various corrosive or hazardous constituents in the effluent gas stream. For example, when processing semi-conductor wafers deposition and etching steps for example exhaust different constituents and they must be treated appropriately. Also, when cleaning a processing chamber between processing
10 steps further constituents will be exhausted from the processing chamber. Additionally, particulates may be entrained in the exhaust stream, and may include sub-micron particulates, which must be collected by the abatement apparatus.

Embodiments of the present invention as described in more detail below seek to provide an improved abatement system.

15 The present invention provides an abatement system for abating effluent gas evacuated from a processing chamber, the abatement system comprising:

a liquid ring pump for compressing and pre-scrubbing gas evacuated from a processing chamber, the liquid ring pump comprising a gas inlet for receiving evacuated gas, a liquid inlet for receiving liquid for generating a liquid ring in a stator of the pump
20 when a rotor rotates in the stator and a gas and liquid outlet for exhausting gas and liquid in a gas/liquid ratio; and

a venturi scrubber comprising an inlet for receiving the gas and liquid mixture from the liquid ring pump, a nozzle through which the gas and liquid is conveyed for providing mixing of the gas with the liquid, and a liquid sump for collecting liquid

conveyed through the nozzle and a gas outlet for exhausting gas from the venturi scrubber, the liquid ring pump being configured to exhaust gas and liquid at a pressure which drives the gas and liquid through the venturi scrubber.

Other preferred and/or optional aspects of the invention are defined in the
5 accompanying claims.

In order that the present invention may be well understood, several embodiments thereof, which are given by way of example only, will now be described with reference to the accompanying drawings, in which:

- Figure 1 shows schematically a first abatement system;
- 10 Figure 2 shows schematically a second abatement system; and
- Figure 3 shows schematically a third abatement system;
- Figure 4 shows schematically a fourth abatement system; and
- Figure 5 shows schematically a fifth abatement system.

Liquid ring pumps have been shown to be effective at separating dust particles
15 from a gas stream providing that the typical particle size is relatively large, typically greater than a micron ($>1\mu\text{m}$). In this respect, liquid ring pumps are comparable to packed wet scrubber towers in their particle collection efficiency. Venturi scrubbers on the other hand, when operated with an appropriate liquid/gas ratio and relatively high pressure drop across the venturi nozzle (throat) have been used to efficiently collect sub-
20 micron particles and their use in collecting silica (SiO_2) fume is well documented.

Venturi scrubbers can easily be operated in a continuous fashion whereas an alternative, such as bag filters, need to be periodically taken offline to empty and clean thus requiring either duplex installation or downtime. A venturi scrubber captures particulates, which may be hazardous, as a damp slurry reducing the risk of re-entrainment of the particles

into the gas stream, contamination on handling, and inhalation by operatives. However, in order to collect sub-micron particles a venturi scrubber needs to be driven by a pressure drop typically around 250 cm of water. Such pressure drop has typically been provided by expansive roots blowers operating upstream or downstream of the scrubber.

5 A vacuum system for evacuating a processing chamber may comprise a dry pumping arrangement connected to the chamber and abatement apparatus such as a wet scrubber or combustor located downstream of the dry pumping arrangement. A venturi scrubber provides a significant resistance to the flow of an effluent gas stream exhausted from a process chamber and therefore is therefore not usually considered appropriate for
10 scrubbing such gas flows. Blowers can be used to provide an additional pressure change required to drive a venturi scrubber, either downstream providing suction or upstream providing compression; however such blowers would need to be resistant to potentially highly corrosive effluent gases and be designed so that they did not to provide an ignition source when used with explosive and flammable gas mixtures.

15 Referring to Figure 1, an abatement system 10 is shown for abating effluent gas 11 evacuated from a processing chamber for example by a dry pumping arrangement (not shown). The dry pumping arrangement evacuates gas at a pressure which may be in the region of 1 mbar to 10^{-6} mbar and exhausts the gas stream at a pressure in the region of atmosphere. The abatement system 10 comprises a liquid ring pump 12 for compressing
20 gas evacuated from a processing chamber. The liquid ring pump comprises a gas inlet 14 for receiving evacuated gas from the dry pumping arrangement, a liquid inlet 16 for receiving liquid from a liquid source 18 for generating a liquid ring in a stator 20 of the pump when a rotor 22 rotates in the stator and a gas and liquid outlet 24 for exhausting gas and liquid in a gas/liquid ratio.

The abatement apparatus further comprises a venturi scrubber 26 comprising an inlet 28 for receiving the gas and liquid mixture from the liquid ring pump, a nozzle (otherwise known as a throat) 30 through which the gas and liquid is conveyed for providing mixing of the gas with the liquid, a liquid sump 32 for collecting liquid conveyed through the nozzle and a gas outlet 34 for exhausting gas from the venturi scrubber.

The liquid ring pump 12 is configured to exhaust gas and liquid at a pressure which drives the gas and liquid through the venturi scrubber. In the case of effluent gas containing corrosive constituents the liquid ring pump is constructed to be resistant to corrosive and flammable gas mixtures. The liquid ring pump co-discharges both gas and service liquid in a ratio suitable for the venturi scrubber for promoting scrubbing within the venturi. The mixture of gas and liquid is discharged by the Liquid Ring Pump at pressure and passes through the restriction provided by nozzle 30 via a compression portion 36. The gas exiting the Liquid Ring Pump, a highly efficient scrubber in itself, is further mixed with the service liquid a second time as the mixture is forced through the nozzle 30 via the compression portion 36. In this regard and depending on the constituents of the effluent gas stream, the corrosive constituents dissolve in or otherwise react with the service liquid, particularly in the turbulent flow generated through the nozzle 30. The large difference in velocity of gas and liquid, as the mixture passes through the nozzle and expands into expansion portion 40, aid the entrapment of particulate through a mechanism of impaction of the fast gas-borne particles on fast moving liquid droplets. The size of the water droplets required to capture a particular particulate is proportional to the size of the particulate they are required to capture; that is a finer (smaller) water droplet is required for collecting smaller particulate. The size of

the liquid droplets is determined by the speed at which the liquid accelerates through the compression section 36 and nozzle 30 and then a shearing action in the expansion portion 40. The expansion portion 40 also serves to separate the gas from the liquid so that the liquid is retained in the sump 32 whereas scrubbed gas is exhausted from the scrubber through outlet 34. The compression and expansion portions 36, 40 as well as the nozzle 30 are configured according to the ratio of the gas liquid mixture entering the venturi scrubber. The key design parameters for the venturi Scrubbers are the throat diameter, total gas flow, liquid to gas ratio and the pressure drop across the nozzle 30. The nozzle diameter, total gas flow and liquid to gas ratio affect the resultant pressure drop. For efficient particle capture high pressure drops, and consequently large differences in gas and liquid velocities, are required whereas for high gas scrubbing efficiency (for example the capture of acidic compounds) lower gas and liquid velocities are required to increase the contact time between the liquid and effluent gas. As the liquid ring pump has already served as an efficient gas scrubber the pressure drop is optimised for particulate collection. Calvert et al (Yung, Barbarika, and Calvert, J. Air Pollut. Control Assoc., 27, 348, (1977)) have developed equations which allow the pressure drop to be calculated from a knowledge of the gas and liquid properties and the physical dimensions of the venturi scrubber. Using these equations it is possible to optimise the gas to liquid ratio and nozzle dimensions to achieve the necessary pressure drop. Fortuitously the gas to liquid ratio discharged by the LRP is generally around $7 \text{ m}^3 \text{ liquid} / 1000 \text{ m}^3 \text{ gas}$ which is within the range of values considered to be optimal for high efficiency particulate capture. Thus for a given total gas load the optimum nozzle dimensions can be easily determined.

In known venturi scrubbers liquid is injected into a liquid inlet of the scrubber from a source of liquid in order to mix with gas entering the venturi through a gas inlet.

The liquid is injected in a controlled manner to form a suitable liquid/gas ratio for promoting particulate scrubbing. Injection of liquid in this way requires additional equipment for both determining the amount of liquid injected and actually injecting the liquid into the scrubber. In the present arrangement, due to the use of a liquid ring pump, gas and liquid enter the venturi scrubber together in a suitable ratio for promoting particulate scrubbing. In general, no additional liquid injection means or means for determining the amount of liquid is required with the possible exception of pressure stabilisation of the venturi inlet that may be required for the second and subsequent embodiments.

10 The venturi scrubber also provides a mechanism for separating the gas and water replacing the separator tank typically used in liquid ring pump installations. The corrosion resistant design of some liquid ring pump permits the use of concentrated acids and thus the service liquid can include recirculated liquid reducing liquid consumption and minimising the waste volume.

15 In the arrangement shown, an optional liquid scrubbing tower 38 is provided for further scrubbing the effluent gas stream. The wet scrubber 38 has an inlet 42 which receives gas from the exhaust 34 of the venturi scrubber. Fresh liquid can be introduced to the tower through a liquid inlet 44 and scrubbed gas is exhausted through outlet 46. The scrubbing liquid cascades down through the tower 38, over the packed materials to form a film of liquid into which the particulate and any soluble materials in the gas stream are captured.

20 The abatement system 10 provides in the form of liquid ring pump 12 highly efficient scrubbing of water soluble and hydrolysable gases and in the form of venturi scrubber 26 a highly efficient means of capturing sub-micron particles. The compression

of the gas stream by the liquid ring pump provides the necessary motive force to the gas to overcome the pressure drop across the nozzle 30 of the venturi scrubber. In this embodiment the exhaust gas/liquid exhausted from the liquid ring pump enters the top of the venturi scrubber in a tangential direction such that the liquid portion of the exhaust fluid is forced to spin around the inside wall of the frusto-conical venturi scrubber portion 36 before falling into the venturi nozzle 30. This spinning action can be further enhanced by running the liquid stream into a channel concentric to, and outside of, the venturi scrubber such that it forms a liquid weir which then generates a continuously washed water wall down the inside of the venturi scrubber. Calculations and experiments have shown that the venturi nozzle size can be easily chosen to suit the liquid/gas ratio emitted by the liquid ring pump and such that a relatively large pressure drop is created (of the order of 250 cm water) to ensure highly efficient scrubbing of particulate matter. If required (for example due to possible variation in process gas flow), control of the pressure drop can be achieved using an additional recirculated liquid supply to the venturi scrubber inlet that can be varied in relation the gas flow and the desired pressure drop.

In subsequent embodiments of this invention a combustion section, comprising an ignition source and oxidant supply, is positioned between the liquid ring pump exhaust and the venturi scrubber, and operated such that the flammable portion of the waste stream (SiH_4 , H_2 etc) can be steadily and safely combusted. A further refinement of this design is that the combustion section is located concentrically within the water weir, as described above, where the water weir is generated from the water exhausted by the liquid ring pump and which flows down the walls of the venturi scrubber inlet.

In more detail, a second embodiment of this invention outlines a combination of liquid ring pump, combustion section and venturi scrubber suitable for abatement of

silane-ammonia mixtures used in the manufacture of silicon nitride (SiN) layers. Using the liquid ring pump upstream of the venturi scrubber to pre-scrub ammonia solves the problem of NO_x generation that occurs in the combustion of ammonia, along with the silane, in conventional atmospheric pressure plasma or combustion abatement systems.

5 To improve the scrubbing efficiency, the liquid ring pump can be dosed with an acid, typically sulphuric acid, to further sequester the ammonia. As any oxidant is introduced to the gas liquid flow downstream of the liquid ring pump, the liquid ring pump need only be configured for pumping the gas stream exhausted from the dry pump rather than if it were located downstream of the combustion section, it would be required to have a
10 greater capacity.

The second embodiment as shown in Figure 2 further comprises a combustion section. The combustion section comprises an oxidant inlet 50, provided for the supply of an oxidant flow into an inlet portion of the venturi scrubber, and an ignition source 52 provided to ignite the effluent gas entering the venturi scrubber. The effluent gas stream
15 mixes with the flow of oxidant, is ignited by the ignition source and thus the effluent gas stream is combusted. The ignition source 52 may be for example a microwave or dc plasma source, fuel/oxidant burner, or electrically heated surface. The oxidant may be for example air or oxygen. The oxidant inlet as shown is formed in the venturi scrubber but in an alternative configuration the inlet may be formed upstream of the venturi inlet 28,
20 and downstream of the liquid ring pump, to form an intimate mixture of effluent gas and oxygen prior to entering the combustion section. In a further refinement to the design the combustion takes place in a space defined at the upper surface of the venturi as shown by the ignition source 52 and oxidant inlet 50 and at its vertical perimeter by the continuously liquid washed wall of the compression section 36 of the venturi scrubber.

Thus the combustion products are swept into the venturi nozzle 30 and the walls of the combustion chamber 36 are kept cool and constantly cleaned.

In the second embodiment one or more compatible effluent gas streams contain, for example, but not limited to, ammonia-silane mixtures used for the manufacture of SiN layers. The liquid ring pump 12, using water as the service liquid and possibly dosed with a chemical such as, but not limited to, sulphuric acid, to enhance the scrubbing efficiency, pre-scrubs the incoming gas stream so that, in the case of ammonia-silane mixtures, the gas phase ammonia concentration is significantly reduced before the gas stream enters the combustion section. The provision of the liquid ring pump upstream of the combustion section, particularly when dosed with sulphuric acid, significantly reduces the formation of NO_x normally observed during the combustion of ammonia containing gas streams.

Another example of an application for this invention is the deposition of silicon layers e.g. Amorphous or microcrystalline silica used in solar cells. The process often uses mixtures of silane, hydrogen and various dopants (PH₃, GeH₃ etc) resulting in highly explosive and flammable exhaust gas streams. The tools used in the manufacturing process have multiple chambers that are periodically, and sometimes independently, cleaned with a fluorine containing gas such as nitrogen trifluoride (NF₃). This results in a waste gas stream containing a highly oxidising mixture of fluorine F₂, silicon tetrafluoride SiF₄ and some residual NF₃. The deposition gas stream must be prevented from mixing with the cleaning step gas stream because of the risk of explosion and fire.

In the third embodiment of this invention a plurality of liquid ring pumps 54, 56, 58 (one per chamber 60, 62, 64 of the production tool 66) feed a single venturi scrubber. In this example, three liquid ring pumps are associated with three chambers of a

production tool. A dry pumping arrangement 68 which may comprise multiple pumps serves to convey, or evacuate, the effluent gas flow 70, 72, 74 from respective processing chambers. The venturi scrubber 26 and wet scrubbing tower 38 are arranged in the same manner shown in and discussed in relation to Figure 2 (or if appropriate as shown in

5 Figure 1 without a combustion section). Each of the liquid ring pumps can be configured for pumping and scrubbing respective effluent gas flows 70, 72, 74, for example, the service liquid of the pump can be selected appropriately for scrubbing the effluent gas flow and/or may be dosed with the appropriate dosing agent such as sulphuric acid as mentioned above. In Figure 3, the liquid ring pumps 54, 56, 58 are connected to

10 respective chambers 60, 62, 64 in parallel such that effluent gas exhausted from each of the chambers has a dedicated liquid ring pump for pumping and scrubbing. In another arrangement, one or more of the liquid ring pumps can be switched in to any one of the chambers, for example, so that one of the liquid ring pumps is arranged to pump effluent gas (e.g. 72) from one chamber 60 during processing and another of the liquid ring pump

15 is arranged to pump effluent gas (e.g. 74) from that chamber 60 during cleaning. This allows the clean step gases (e.g. F₂ and SiF₄) to be pre-scrubbed before entering the venturi scrubber and thus eliminates the possibility of incompatible gas streams mixing. An additional benefit of this embodiment is that using a liquid ring pump can generate a reduced pressure in the exhaust lines of the conventional dry pumps, reducing their power

20 consumption and improving the pumping speeds of hydrogen through the system. In this regard, the dry pump or pumps may be arranged to exhaust at a pressure below atmosphere and the respective liquid ring pumps are arranged to increase pressure of the pumped gas sufficiently to drive the venturi scrubber for example to 250 cm of water. The same efficiency saving can be applied to any of the embodiments described herein.

The third embodiment, and subsequent embodiments, of this invention concerns the abatement of multiple gas streams 72, 74, 76 where there is a possibility that the gas streams may be incompatible with each other. The incompatibility of the gas streams is avoided by prior scrubbing by respective liquid ring pumps. For example, in the

5 manufacture of silicon layers, gas mixtures containing silane, hydrogen and various dopants (e.g. Phosphine and Germane) are used for the actual deposition chemistry but the production tool, often equipped with multiple, independently controlled, chambers 60, 62, 64 also periodically use mixtures of fluorine containing gases (e.g. Nitrogen trifluoride) to plasma clean the chambers. This cleaning step liberates highly oxidising

10 waste gas streams containing, among other things, fluorine, silicon tetrafluoride and residual nitrogen trifluoride. The mixing of the highly flammable deposition chemicals (e.g. Silane, hydrogen) with the clean step gases and their reaction by-products must be prevented because of the obvious risk of fire and explosion. To that end, in the third

15 embodiment of this invention, each process chamber waste gas stream 72, 74, 76 exiting the dry pumps 68 enters a separate liquid ring pump for independent pre-scrubbing. In the example given above for silicon layer deposition the liquid ring pumps scrub the fluorine containing species (with the exception of the nitrogen trifluoride) before it enters the combustion section so preventing the mixing of incompatible gas streams. Also, the additional pumping by the liquid ring pump also improves the speed of pumping of

20 molecular hydrogen containing gas streams and reduces the power consumption of the dry pumps.

In the fourth embodiment of this invention two liquid ring pumps are employed. A first liquid ring pump is arranged to pump the deposition gases and a second liquid ring pump is arranged to pump the cleaning step gases with foreline valves and pipework to

direct clean and deposition gases to the appropriate first and second liquid ring pumps.

These two liquid ring pumps then feed a single venturi scrubber. The venturi scrubber 26 and the optional scrubbing tower 38 are as described previously in Figures 1, 2 or 3.

5 This also allows the clean step gas stream (e.g. F_2 and SiF_4) to be pre-scrubbed before entering the combustion section and venturi scrubber and thus eliminates the possibility of incompatible gas streams mixing. Like the third embodiment the use of a liquid ring pump generates a reduced pressure in the exhaust lines of the conventional dry pumps, reducing their power consumption and improving the hydrogen pumping speeds.

10 As shown in Figure 4, in the fourth embodiment the requirement for an individual liquid ring pump or liquid ring pumping stage per process chamber 60, 62, 64 is avoided by using a bank of 3-way valves, one per process chamber (or per processing/cleaning step or stage), to direct the process flows to one of a fewer number of liquid ring pumps, or two liquid ring pumps for three chambers/steps as shown in Figure 4. The venturi scrubber 26 and tower 38 as shown are as shown in, and discussed in relation to, Figure 2
15 (or if appropriate as shown in Figure 1 without a combustion section). One liquid ring pump 78 is arranged for receiving the deposition waste gas stream 82 and one liquid ring pump 80 for receiving the clean gas waste stream 84. In more detail, three valves 86, 88, 90, which are preferably at least three-way valves, are provided for conveying gas from a chamber to a selected one of the liquid ring pumps 78, 80. For example, effluent gas
20 exhausted from chamber 60 during a processing step is conveyed to liquid ring pump 78 by valve 86 and during a chamber cleaning step is conveyed to liquid ring pump 80. Liquid ring pumps 78, 80 may be configured respectively for treating processing gas effluent streams and cleaning gas effluent streams. Alternatively, one liquid ring pump 78 could be configured for treating effluent gas exhausted during a first process step, for

example a deposition step whilst a the second liquid ring pump 80 could be configured for treating gas exhausted during a second processing step, for example an etching step. The deposition waste gas stream can then be directed into the combustion section as outlined in the second embodiment or as detailed below in the fifth embodiment directly
5 into the ignition source.

In both the third and fourth embodiments the deposition gas streams are conveyed through a liquid ring pump 54, 56, 58; 78, 80. Although the typical constituents of the deposition streams do not react with, or dissolve in, water the gas stream is often laden with particles. A significant portion of the particles are removed by the passage through
10 the liquid ring pump, particularly micron sized particles or above, reducing the burden on the combustion section where such particle laden gas streams could potentially cause blockages.

In the fifth embodiment of this invention, foreline valves and pipework direct the clean step gases to a single liquid ring pump for pre-scrubbing and the deposition gases
15 directly into the combustion section within a single venturi scrubber.

In the fifth embodiment shown in Figure 5, a bank of 3-way valves 86, 88, 90 as described in the fourth embodiment are used to selectively convey effluent gas 82, 84 from a chamber 60, 62, 64 to one of a plurality of liquid ring pumps 78, 80. In one arrangement, the clean and deposition step effluent gas streams are conveyed to
20 respective liquid ring pumps for pre-scrubbing so that the clean and processing step effluent gas stream do not become mixed prior to pre-scrubbing by the liquid ring pumps. Pre-scrubbing conditions the effluents gas streams so that the potential hazard associated with mixing the gas streams is reduced. The deposition waste gas stream (including gas and service liquid), after pre-scrubbing and compression in the liquid ring pump, is

conveyed to a gas and liquid separator 92. The gaseous portion 94 is conveyed into oxidant supply nozzle 50 of the combustion section for pre-combustion. The liquid portion 96 of the pre-scrubbed deposition waste gas stream drains into the inlet 28 of the venturi scrubber 26. The cleaning step effluent gas stream is conveyed to the inlet 28 of the venturi scrubber 26 without passing through the separator 92. This arrangement increases the degree of separation of deposition waste gas from clean step waste gas enhancing the safety of the operation. Allowing the clean step waste gas stream to mix with the already pre-combusted deposition waste gas stream enhances the destruction of fluorine containing species remaining in the gas stream after-scrubbing in the liquid ring pump, in particular the residual nitrogen trifluoride.

CLAIMS

1. An abatement system for abating effluent gas evacuated from a processing chamber, the abatement system comprising:
5 a liquid ring pump for compressing and pre-scrubbing gas evacuated from a processing chamber, the liquid ring pump comprising a gas inlet for receiving evacuated gas, a liquid inlet for receiving liquid for generating a liquid ring in a stator of the pump when a rotor rotates in the stator and a gas and liquid outlet for exhausting gas and liquid in a gas/liquid ratio; and
10 a venturi scrubber comprising an inlet for receiving the gas and liquid mixture from the liquid ring pump, a nozzle through which the gas and liquid is conveyed for providing mixing of the gas with the liquid, and a liquid sump for collecting liquid conveyed through the nozzle and a gas outlet for exhausting gas from the venturi scrubber, the liquid ring pump being configured to exhaust gas and liquid
15 at a pressure which drives the gas and liquid through the venturi scrubber.
2. An abatement system as claimed in claim 1, wherein the gas/liquid ratio of the effluent gas stream exhausted from the liquid ring pump is adapted to promote scrubbing by the venturi scrubber.
20
3. An abatement system as claimed in claim 1 or 2, comprising a combustor located to combust effluent gas exhausted from the liquid ring pump prior to passage of the gas stream through the nozzle of the venturi scrubber.

4. An abatement system as claimed in claim 3, wherein the combustor comprises an oxidant inlet for the supply of an oxidant flow into an inlet portion of the venturi scrubber and an ignition source located to ignite the effluent gas entering the venturi scrubber in the flow of oxidant for combusting the effluent gas stream.
5
5. An abatement system as claimed in claim 4, wherein the oxidant inlet is formed in the venturi scrubber and the ignition source extends into the venturi scrubber for combusting effluent gas in the venturi scrubber.
- 10 6. An abatement system as claimed in any one of the preceding claims, comprising a plurality of said liquid ring pumps arranged for compressing and pre-scrubbing effluent gas exhausted from respective processing chambers, wherein the liquid rings pumps are configured for the respective effluent gas streams exhausted by said chambers.
15
7. An abatement system as claimed in any one of the preceding claims, comprising a plurality of said liquid ring pumps arranged for compressing and pre-scrubbing effluent gas exhausted during respective processing and cleaning steps in one or more process chambers, wherein the liquid rings pumps are configured for the
20 respective effluent gas streams exhausted during processing and cleaning steps.
8. An abatement system as claimed in claim 6 or 7, wherein said plurality of liquid ring pumps exhaust an effluent gas and liquid mixture to said venturi scrubber.

9. An abatement system as claimed in any one of claims 6 to 8, comprising at least one valve located between a said process chamber and the plurality of liquid ring pumps for conveying effluent gas exhausted from said processing chamber to a selected one of said liquid ring pumps dependent on the step carried out in the process chamber during which effluent gas is generated.
- 5
10. An abatement system as claimed in claim 9, wherein said valve is a three way valve and conveys effluent gas generated during a process step to a first said liquid ring pump and effluent gas generated during a cleaning step to a second said liquid ring pump.
- 10
11. An abatement system as claimed in claim 9 or 10, comprising a plurality of valves located between respective process chambers and the liquid ring pumps for conveying effluent gas exhausted from respective said process chambers to a selected one of the liquid ring pumps dependent on the step carried out in the process chamber during which effluent gas is generated.
- 15
12. An abatement system as claimed in claim 11, wherein said valves are three way valves and convey effluent gas generated in respective process chambers during a process step to a first said liquid ring pump and effluent gas generated during a cleaning step to a second said liquid ring pump.
- 20
13. An abatement system as claimed in any one of the preceding claims, wherein the venturi scrubber comprises a generally conical inlet portion upstream of the

nozzle and the inlet of the venturi scrubber is arranged to convey the gas and liquid mixture tangentially to the conical inlet portion such that the liquid portion of the mixture is forced to spin around the inside wall of the venturi scrubber portion.

5

14. An abatement system as claimed in any one of the preceding claims, comprising a wet scrubber located downstream of the venturi scrubber for wet scrubbing gas exhausted from the venturi scrubber.

10

15



Application No: GB1512898.6

Examiner: Beverley Lloyd

Claims searched: 1 - 14

Date of search: 22 January 2016

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	1 - 14	EP2631280 A1 (METSO POWER) See Fig & EPODOC Abstract

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :

Worldwide search of patent documents classified in the following areas of the IPC

B01D; C23C; F04C

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
B01D	0053/75	01/01/2006
B01D	0047/10	01/01/2006
F04C	0019/00	01/01/2006