METHOD AND DEVICE FOR REMOVING POLLUTION FROM A CONFINED ENVIRONMENT.

TECHNICAL FIELD OF THE INVENTION

The invention pertains to the cleaning and depollution of unsealed confined environments, particularly including storage and transport pods for semiconductor substrates, agrifood products, medical or automobile products, or photomasks equipped with their protective films.

Storage and transport pods under atmospheric pressure for one or more substrates, particularly for semiconductor wafers, define an enclosed space separated from the environment in which the substrates are used and transported by a peripheral wall equipped with an opening through which subtrates may pass, covered by a door. This type of transport pod is most commonly made of plastic and is not generally sealed when in service. The plastic peripheral wall is not designed to withstand pressures greater than a few tens of atmospheres without sustaining damage. The transport pods are therefore designed with at least one leak, so that when a difference in pressure exists between the interior and exterior of the box, a gas flow occurs to minimize the difference in pressure and thereby reduce the mechanical stress on the peripheral wall. For FOUP transport pods, a particle filter is placed inside the leak to reduce pollution. Normally, the atmosphere within the pod is uncontrolled, and it is assumed that it is most commonly similar to that of the equipment from which the substrates have exited, or the ambient air near the transport pod.

The transport pods are generally effective at preventing polluting particles from penetrating into the confined space. Their usage is made necessary by the increasing need to reduce particle pollution, particularly when manufacturing semiconductors and other nanotechnology products. However, the plastic peripheral walls of the transports pods may leak gas, or may maintain or add compounds that may react with the substrates and pollute them. These compounds may, in particular, come from an inadequate environment (such as one in which humidity is present) during certain phases in the manufacturing of the substrates. This environment is then maintained by the internal atmosphere of the transport pods. Thus, the transport pods are insufficient at preventing all danger of pollution, and furthermore may in certain cases even contribute to additional pollution (gas leaking through the walls, retaining humidity, cross-contamination, opening/closing mechanisms that generate particles, lack of air-tightness in the walls, etc.)

The document EP 1,557,878 describes the purging of a stack of substrate wafers placed inside a sealed mini-environment chamber, equipped with an access hole that may be covered with a lower door, and filled with air, for example. The chamber is connected by its lower surface to a purging station comprising a purging compartment equipped with an upper transfer hole that may be closed, facing the lower surface of the chamber, by opening the lower door; a stack of substrate wafers supported by the lower door is inserted into the purging compartment, which had been filled with nitrogen beforehand. At the same time that the spaces between the substrate wafers are purged, the interior of the mini-environment chamber is purged through penetration, and gas is expelled through the closable access hole, which at this point is open. An analysis of the interior atmosphere of the chamber is performed in order to test its quality.

CLAIMS

1. A method for decontaminating an unsealed enclosed environment (1) comprising an inner space (2) delimited by a wall (3) having a natural leak (4), comprising the following steps:

- the unsealed enclosed environment (1), having its natural leak (4), is placed within a sealed decontamination chamber (5) comprising means for introducing gas (6) and means for pumping out gas (7, 8),

- the gas contained within the decontamination chamber (5) is pumped out by adjusting the pressure drop within the decontamination chamber (5) in such a way so that the difference in pressure between the interior and exterior of the unsealed enclosed environment (1) is at all times less than the difference in pressure that would cause mechanical warping that would damage the wall (3) of the unsealed enclosed environment (1).

2. A method according to claim 1, characterized in that it comprises a step of raising pressure, during which the increase in pressure within the decontamination chamber (5) is adjusted so that the difference in pressure between the interior and exterior of the unsealed enclosed environment (1) is at all times less than the difference in pressure that would cause mechanical warping that would damage the wall (3) of the unsealed enclosed environment (1).

3. A method according to claim 1, wherein the variation in pressure within the decontamination chamber (5) is controlled by following a theoretical curve of pressure versus time.

4. A method according to claim 1, wherein the variation in pressure within the decontamination chamber (5) is controlled by following a signal given by at least one sensor detecting warping in the wall (3) of the unsealed enclosed environment (1).

5. A method according to claim 1, characterized in that, to adjust the change in pressure within the decontamination chamber (5), the pumping capacity of the pumping means (7, 8) is varied, by controlling their rotational velocity, and/or by controlling a variable conductance (12) of the pumping means, and/or a gas flow entering the decontamination chamber (5) is varied by controlling the means for introducing gas (6)

6. A method according to claim 1, further comprising a step of purging, said step of purging comprising at least one operation of filling with purging gas, during which a purging gas is introduced into the decontamination chamber (5).

7. A method according to claim 6, characterized in that the sub of purging further comprises at least one purging gas pumping operation during which the mixture of the gas present in the decontamination chamber (5) is extracted therefrom.

8. A method according to claim 7, wherein the purging gas filling and pumping operations are performed simultaneously, with a pumping flow rate less than the injection flow rate.

9. A method according to claim 7, wherein multiple purging gas filling and pumping operations are performed in succession.

10. A method according to claim 6, wherein multiple purging steps, comprising purging gas filling and pumping operations, alternate with pumping steps.

11. A method according to claim 6, wherein the purging gas filling operation comprises an overpressure period, during which the decontamination chamber (5) is kept at a pressure greater than atmospheric pressure, before being returned to atmospheric pressure.

12. A method according to claim 6, wherein the purging gas is nitrogen.

13. A method according to claim 6, wherein the purging gas is introduced into the unsealed enclosed environment (1), and extracted therefrom, through the filters (35) that said environment comprises.

14. A method according to claim 1, wherein the unsealed enclosed environment (1) being a photomask equipped with its film (3), the purging gas is introduced and extracted through the low-conductance filters separating the film from the active part of the mask.

15. A method according to claim 1, characterized in that the unsealed enclosed environment (1) is a closed atmospheric transport pod.

16. A method according to claim 15, characterized in that the transport pod contains semiconductor substrate wafers (100).

17. A method according to claim 1, wherein low pressures, of about 10^{-2} to 10^{-3} Torr, are achieved within the decontamination chamber (5).

18. A method according to claim 1, wherein the gases pumped are analyzed, and the pumping step is halted once the level of pollution inside the sealed decontamination chamber (5) becomes less than a preset value.

19. A device for decontaminating an unsealed enclosed environment (1), comprising:

- a decontamination chamber (5) capable of containing the unsealed enclosed environment (1),

- means for introducing gas (6, 13), capable of producing a gas injection flow within the decontamination chamber (5),

- pumping means (7, 8), capable of pumping the gases out of the decontamination chamber (5),

characterized in that:

- the pumping means (7, 8) have a variable pumping capacity,

- command means (14) are provided to adjust the pumping capacity and adjust the gas injection flow,

- means for controlling the difference in pressure between the interior and exterior of the unsealed enclosed environment (1) are provided,

the command means (14) adjust the pumping capacity and/or the gas injection flow so that the difference in pressure between the interior and exterior of the unsealed enclosed environment (1), determined by the means for controlling the difference in pressure, is at all times less than the difference in pressure that would cause mechanical warping that would damage the wall (3) of the unsealed enclosed environment (1).

20. A device according to claim 19, wherein the means for controlling the difference in pressure comprise a theoretical curve of pressure versus time, saved in the memory (14b) of the command means (14), and which the command means (14) follow in order to vary the pumping capacity and/or gas injection flow over time.

21. A device according to claim 19, characterized in that the means for controlling the difference in pressure comprise at least one warping sensor (15), adapted to measure the warping of the wall (3) of the unsealed enclosed environment (1), and providing a signal for controlling the variation in pressure within the decontamination chamber (5).

22. A device according to claim 19, further comprising means for heating the unsealed enclosed environment (1).

23. A device according to claim 19, wherein the means for introducing gas (6, 13) comprise a source of purging gas, such as nitrogen or synthetic air.

24. A device according to claim 19, further comprising pumped gas analysis means (11).

25. A device according to claim 24, wherein the analysis means (11) comprise means for ionizing the pumped gases, means for identifying the ionized gases by measuring an ion parameter, and means for performing an operation on the measured parameters.

26. A device according to claim 24, characterized in that the pumping and purging steps are automated and are triggered by reading signals from the pumped gas analysis means (11) and/or a warping sensor (15).

27. A device according to claim 19, wherein the decontamination chamber (5) is of dimensions slightly greater than those of the unsealed enclosed environment (1).

28. A device according to claim 19, further comprising measuring means (10) for measuring the change in pressure within the decontamination chamber (5).

29. A device according to claim 19, wherein the pumping means (7, 8) comprise a primary pump (8a) and a secondary pump (8b), which may be a molecular, turbomolecular, or hybrid pump, and finding a pumping to capable of establishing a vacuum of about 10^{-2} to 10^{-3} Torr within the decontamination chamber (5).

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The transport pods are generally effective at preventing polluting particles from penetrating into the confined space. Their usage is made necessary by the increasing need to reduce particle pollution, particularly when manufacturing semiconductors and other nanotechnology products. However, the plastic peripheral walls of the transports pods may leak gas, or may maintain or add compounds that may react with the substrates and pollute them. These compounds may, in particular, come from an inadequate environment (such as one in which humidity is present) during certain phases in the manufacturing of the substrates. This environment is then maintained by the internal atmosphere of the transport pods. Thus, the transport pods are insufficient at preventing all danger of pollution, and furthermore may in certain cases even contribute to additional pollution (gas leaking through the walls, retaining humidity, cross-contamination, opening/closing mechanisms that generate particles, lack of air-tightness in the walls, etc.)

The document EP 1,557,878 describes the purging of a stack of substrate wafers placed inside a sealed mini-environment chamber, equipped with an access hole that may be covered with a lower door, and filled with air, for example. The chamber is connected by its lower surface to a purging station comprising a purging compartment equipped with an upper transfer hole that may be closed, facing the lower surface of the chamber, by opening the lower door; a stack of substrate wafers supported by the lower door is inserted into the purging compartment, which had been filled with nitrogen beforehand. At the same time that the spaces between the substrate wafers are purged, the interior of the mini-environment chamber is purged through penetration, and gas is expelled through the closable access hole, which at this point is open. An analysis of the interior atmosphere of the chamber is performed in order to test its quality.

The invention claimed is:

1. A method for decontaminating an unsealed enclosed environment (1) comprising an inner space (2) delimited by a wall (3) having a natural leak (4), comprising the following steps:

the unsealed enclosed environment (1), having its natural leak (4), is placed within a sealed decontamination chamber (5) comprising means for introducing gas (6) and means for pumping out gas (7, 8),

the gas contained within the decontamination chamber (5) is pumped out by adjusting the pressure drop within the decontamination chamber (5) in such a way so that the difference in pressure between the interior and exterior of the unsealed enclosed environment (1) is at all times less than the difference in pressure that would cause mechanical warping that would damage the wall (3) of the unsealed enclosed environment (1).

2. A method according to claim 1, wherein a step of raising pressure is comprised, during which the increase in pressure within the decontamination chamber (5) is adjusted so that the difference in pressure between the interior and exterior of the unsealed enclosed environment (1) is at all times less than the difference in pressure that would cause mechanical warping that would damage the wall (3) of the unsealed enclosed environment (1).

3. A method according to claim 1, wherein the variation in pressure within the decontamination chamber (5) is controlled by following a theoretical curve of pressure versus time.

4. A method according to claim 1, wherein the variation in pressure within the decontamination chamber (5) is controlled by following a signal given by at least one sensor detecting warping in the wall (3) of the unsealed enclosed environment (1).

5. A method according to claim 1, wherein to adjust the change in pressure within the decontamination chamber (5), the pumping capacity of the pumping means (7, 8) is varied, by controlling their rotational velocity, and/or by controlling a variable conductance (12) of the pumping means, and/or a gas flow entering the decontamination chamber (5) is varied by controlling the means for introducing gas (6).

6. A method according to claim 1, further comprising a step of purging, said step of purging comprising at least one operation of filling with purging gas, during which a purging gas is introduced into the decontamination chamber (5).

7. A method according to claim 6, wherein the sub of purging further comprises at least one purging gas pumping operation during which the mixture of the gas present in the decontamination chamber (5) is extracted therefrom.

8. A method according to claim 7, wherein the purging gas filling and pumping operations are performed simultaneously, with a pumping flow rate less than the injection flow rate.

9. A method according to claim 7, wherein multiple purging gas filling and pumping operations are performed in succession.

10. A method according to claim 6, wherein multiple purging steps, comprising purging gas filling and pumping operations, alternate with pumping steps.

11. A method according to claim 6, wherein the purging gas filling operation comprises an overpressure period, during which the decontamination chamber (5) is kept at a pressure greater than atmospheric pressure, before being returned to atmospheric pressure.

12. A method according to claim 6, wherein the purging gas is nitrogen.

13. A method according to claim 6, wherein the purging gas is synthetic air.

14. A method according to claim 6, wherein the purging gas is introduced into the unsealed enclosed environment (1), and extracted therefrom, through the filters (35) that said environment comprises.

15. A method according to claim 1, wherein the unsealed enclosed environment (1) being a photomask equipped with its film (3), the purging gas is introduced and extracted through the low-conductance filters separating the film from the active part of the mask.

16. A method according to claim 1, wherein the unsealed enclosed environment (1) is a closed atmospheric transport pod.

17. A method according to claim 16, wherein the transport pod contains semiconductor substrate wafers (100).

18. A method according to claim 1, wherein low pressures, of about 10^{-2} to 10^{-3} Torr, are achieved within the decontamination chamber (5).

19. A method according to claim 1, wherein the gases pumped are analyzed, and the pumping step is halted once the level of pollution inside the sealed decontamination chamber (5) becomes less than a preset value.

20. A device for decontaminating an unsealed enclosed environment (1), comprising:

a decontamination chamber (5) capable of containing the unsealed enclosed environment (1),

means for introducing gas (6, 13), capable of producing a gas injection flow within the decontamination chamber (5),

pumping means (7, 8), capable of pumping the gases out of the decontamination chamber (5),

wherein:

the pumping means (7, 8) have a variable pumping capacity,

command means (14) are provided to adjust the pumping capacity and adjust the gas injection flow,

means for controlling the difference in pressure between the interior and exterior of the unsealed enclosed environment (1) are provided,

the command means (14) adjust the pumping capacity and/or the gas injection flow so that the difference in pressure between the interior and exterior of the unsealed enclosed environment (1), determined by the means for controlling the difference in pressure, is at all times less than the difference in pressure that would cause mechanical warping that would damage the wall (3) of the unsealed enclosed environment (1).

21. A device according to claim 20, wherein the means for controlling the difference in pressure comprise a theoretical curve of pressure versus time, saved in the memory (14*b*) of the command means (14), and which the command means (14) follow in order to vary the pumping capacity and/or gas injection flow over time.

22. A device according to claim 20, wherein the means for controlling the difference in pressure comprise at least one warping sensor (15), adapted to measure the warping of the wall (3) of the unsealed enclosed environment (1), and providing a signal for controlling the variation in pressure within the decontamination chamber (5).

23. A device according to claim 20, further comprising means for heating the unsealed enclosed environment (1).

24. A device according to claim 20, wherein the means for introducing gas (6, 13) comprise a source of purging gas, this gas being nitrogen or synthetic air.

25. A device according to claim **20**, further comprising pumped gas analysis means (**11**).

26. A device according to claim **25**, wherein the analysis means (**11**) comprise means for ionizing the pumped gases, means for identifying the ionized gases by measuring an ion parameter, and means for performing an operation on the measured parameters.

27. A device according to claim **25**, wherein the pumping and purging steps are automated and are triggered by reading signals from the pumped gas analysis means (**11**) and/or a warping sensor (**15**).

28. A device according to claim **20**, wherein the decontamination chamber (**5**) is of dimensions slightly greater than those of the unsealed enclosed environment (**1**).

29. A device according to claim **20**, further comprising measuring means (**10**) for measuring the change in pressure within the decontamination chamber (**5**).

30. A device according to claim **20**, wherein the pumping means (**7**, **8**) comprise a primary pump (**8***a*) and a secondary pump (**8***b*), and capable of establishing a vacuum of about 10^{-2} to 10^{-3} Torr within the decontamination chamber (**5**).