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WET ABATEMENT SYSTEM FOR WASTE SiH_4

BACKGROUND OF THE INVENTION



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(1) Field of the Invention

The invention relates to a method of and device for abatement of waste SiH_4 in the fabrication of integrated circuits, and more particularly, to a method of and device for safe wet abatement of waste SiH_4 in the manufacture of integrated circuits.

(2) Description of the Prior Art

Chemical vapor deposition (CVD) processes are widely used in integrated circuit manufacturing. For example, polysilicon or silicon dioxide layers can be deposited by CVD using silane (SiH_4) gas or other similar gases. After the CVD process has been completed, excess silane gas remains in the CVD system. Typically, excess reactant gases are removed by an exhaust system. The exhaust system may vent the reactant gas to the atmosphere. However, silane gas is pyrophoric and cannot be released into the atmosphere. Silanes and similar gases must be filtered from the exhaust gas stream or converted to compounds that can be disposed of safely. A common method of converting waste silane to a disposable compound is through combustion in a

so-called "burn box". In the burn box, the SiH_4 is converted to SiO_2 by the reaction: $2\text{SiH}_4 + 2\text{O}_2 \rightarrow 2\text{SiO}_2 + 4\text{H}_2$.

However, the risk is that the burn box may be a source of fire if system failure occurs suddenly. For example, if the exhaust system fails, residue SiH_4 will collect in the burn box making it likely that an uncontrolled fire will start.

U.S. Patents 6,174,349 to DeSantis, 6,126,906 to Imamura, and 5,183,646 to Anderson et al describe processes and devices including burn boxes. Wet scrubbers and other abatement methods are also used. U.S. Patent 6,174,349 to DeSantis teaches a wet scrubber in combination with the burn box. U.S. Patent 5,955,037 to Holst et al shows an oxidation treatment. U.S. Patent 5,320,817 to Hardwick et al uses an amine-forming metal salt to scrub silane.

SUMMARY OF THE INVENTION

Accordingly, a principal object of the present invention is to provide an effective and very manufacturable method of silane abatement in the fabrication of integrated circuit devices.

Another object of the present invention is to provide an effective and very manufacturable method of silane abatement wherein the abatement system does not present the danger of being a source of fire.

Another object of the invention is to provide a silane abatement system that does not present the danger of being the source of fire.

In accordance with the objects of this invention a new method of silane abatement is achieved. Waste silane gas is bubbled into a water-filled chamber. The waste silane gas is reacted with oxygen in water in the water-filled chamber whereby SiO_2 precipitates are formed and wherein the SiO_2 precipitates settle to a bottom surface of the water-filled chamber. The SiO_2 precipitates are drained out of the water-filled chamber to complete the abatement process.

Also in accordance with the objects of this invention a new silane abatement system is achieved. The silane abatement system comprises a water-filled chamber within an outer chamber. An air intake is located in one upper portion of the outer chamber and an exhaust output is located in another upper portion of the outer chamber. A

silane gas intake pipe runs into the outer chamber and has its output under water in the water-filled chamber. A drain is connected through a valve at a bottom portion of the water-filled chamber. Many safety features are built into the wet abatement system, including temperature and water level sensors, water sprinklers, and means for shutting off air supply, exhaust, and silane intake.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings forming a material part of this description, there is shown:

Figs. 1 and 2 schematically illustrate in cross-sectional representation a preferred embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention provides a method and a device for waste silane abatement. The waste silane abatement system of the present invention successfully deals with the waste silane without danger of being a fire source. No burn box is used in the method and device of the invention. Rather, waste SiH_4 gas is reacted with dissolved

oxygen to form solid SiO_2 which can be disposed of safely. Safety features of the device of the present invention include sprinklers that will be automatically triggered in the event of fire.

Figs. 1 and 2 illustrate the waste SiH_4 abatement system of the present invention. Referring now to Fig. 1, waste abatement device 10 is shown. A portion of the device is filled with water 22. Oxygen gas is dissolved in the water 22. Waste SiH_4 gas enters the chamber 10 from through a pressurized pipe 18. High pressure N_2 gas flow 19 pushes the SiH_4 gas through the pipe 18, into the chamber 10 and out through the pipe 24 under the water. N_2 gas here is used to prevent back fire to the process tool. If backfire occurs, N_2 is activated to push the fire into the water chamber. The N_2 gas flow is at a high pressure of about 100 psi.

The SiH_4 gas is bubbled into the water 22. Fig. 2 is a close-up of the pipe 24. The waste SiH_4 gas is pumped through pipe 18 into a C-shaped stainless steel square pipe 24. Flippers 14 are pushed upward by pressure to release SiH_4 gas for reaction with dissolved O_2 for abatement. In water at 25 °C, there is about 8.4 ppm of dissolved O_2 . The gas reacts with dissolved oxygen in the

water to form a heavy precipitate of SiO_2 . The SiO_2 precipitate sinks slowly to the base of the chamber. The drain valve 26 is opened, subject to the SiO_2 level, to clear the solid SiO_2 out through the drain 28. Most likely, the drain valve may be opened once a day.

Chamber 20 provides for water overflow. Continuous fresh air intake 30 into the chamber 10 insures the process of oxygen dissolving into the water from the air is not interrupted. An open-ended drain 36 in the chamber 20 will capture water over-flow from the water-filled section 22 of the chamber. An exhaust pipe 38 is separated from the chamber 10 by an exhaust flipper 32. The exothermic abatement process may release smoke into the chamber. This smoke is exhausted into the pipe 38. The exhaust pipe also provides forced air ventilation from the chamber outside into chamber 10 for the air dissolving process.

A controller 34 controls the water supply 42 and fusible link 44. The controller also monitors a water temperature sensor 46, a water level sensor 48, and an exhaust temperature sensor 50. Water sprinklers 52 located in the chamber ceiling and in the exhaust pipe are triggered by the controller by a high water temperature, high exhaust pipe temperature, or when the fusible link is broken. The

fusible link is a burnable material such as nylon. If this link is exposed to heat high enough to break it, the controller will turn on the water sprinklers. The water level sensor avoids "dry-run" operations if the water level is not high enough.

If a minor explosion occurs within the chamber 10, the air intake 30 and the exhaust flipper 32 will shut. The flippers are normally open, but will be pushed closed by the pressure of an explosion. The oxygen source will also be cut off to stop any fire. That is, the air intake flipper 30, normally open, will be pushed closed by pressure due to fire. If the fusible link 49 within one or both of the N₂ high pressure pipes is broken, indicating high heat, high pressure N₂ flow 19 will be triggered to push the fire back into the water chamber 22 and to form N₂ blanketing to stop a fire.

The wet abatement system of the present invention consists of a water-filled chamber within an outer chamber. An air intake flipper and an exhaust flipper control input and output of air. A drain is connected through a valve to the water-filled chamber. An overflow drain is at the bottom of the outer chamber. A controller controls the water supply and monitors the water level, water

temperature, exhaust temperature, and a fusible link within the exhaust pipe. A pipe brings waste SiH_4 gas into the water-filled chamber. A high pressure pump pushes the waste gas through the pipe.

In the wet abatement process of the present invention, waste silane gas is bubbled into the water-filled chamber of the wet abatement system of the present invention. N_2 gas at high pressure pushes the silane gas through a pipe into the water-filled chamber. The silane gas reacts with oxygen dissolved in the water to form a precipitate of SiO_2 . The SiO_2 settles to the bottom of the chamber and is removed from the chamber through a drain.

The process of the present invention abates waste SiH_4 in the water state. The abatement system will not be a source of fire because of the safety features of the wet abatement system of the present invention. These safety features include: water sprinklers located on the ceiling of the outer chamber above the water-filled chamber and in the exhaust pipe, air intake and exhaust flippers that close in the event of an explosion, a process pump trip, fusible links located within the exhaust pipe and within the N_2 pipes that will break if exposed to high heat, water temperature and exhaust temperature sensors, and a water level sensor. The

controller monitors the sensors and the fusible links. If either of the temperature sensors show a high temperature or if any of the fusible links are broken, the water sprinklers are triggered, the air intake and exhaust flippers are closed, the oxygen supply into the chamber is cut off, and the N₂ gas pump is shut down after pushing residue waste gas into the water-filled chamber. If the water level sensor shows the water level is too low, the system is also shut down.

The process and device of the present invention provide wet silane abatement without danger of fire from the abatement system. The wet abatement system of the present invention has a variety of safety features that work together to provide safe and effective silane abatement.

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

What is claimed is:

1. A silane abatement system comprising:
 - a water-filled chamber within an outer chamber;
 - an air intake in one upper portion of said outer chamber;
 - 5 an exhaust output in another upper portion of said outer chamber;
 - a silane gas intake pipe running into said outer chamber and having its output under water in said water-filled chamber; and
 - 10 a drain connected through a valve at a bottom portion of said water-filled chamber.
2. The silane abatement system according to Claim 1 wherein said output of said silane gas intake pipe is into a C-shaped stainless steel pipe having upwardly opening flippers whereby silane gas is released into water within said water-filled chamber.
3. The silane abatement system according to Claim 1 wherein said air intake and said exhaust output both comprise inwardly opening flippers.
4. The silane abatement system according to Claim 1 further comprising an overflow drain at a bottom portion of said outer chamber.

5. The silane abatement system according to Claim 1 further comprising:

a water supply pipe connected to said water-filled chamber;

a water level sensor connected to said water-filled chamber; and

a water temperature sensor connected to said water-filled chamber.

6. The silane abatement system according to Claim 5 further comprising a controller that controls said water supply and monitors said water level sensor and said water temperature sensor.

7. The silane abatement system according to Claim 6 wherein in the event that said controller detects an unacceptable condition from either of said water level sensor or said water temperature sensor, said air intake and said exhaust output are closed, and residue waste silane gas within said silane gas intake pipe is pumped into said water-filled chamber.

8. The silane abatement system according to Claim 1 further comprising:

an exhaust pipe exiting said outer chamber through

said exhaust output;

an exhaust temperature sensor connected to said exhaust pipe; and

a fusible link within said exhaust pipe.

9. The silane abatement system according to Claim 8 wherein in the event that an unacceptable condition is detected in either of said exhaust temperature sensor or said fusible link, said air intake and said exhaust output are closed, and residue waste silane gas within said silane gas intake pipe is pumped into said water-filled chamber.

10. The silane abatement system according to Claim 1 further comprising a high pressure pump connected to said silane gas intake pipe.

11. The silane abatement system according to Claim 10 wherein said high pressure pump provides N_2 gas for pushing silane gas through said gas intake pipe into said water-filled chamber.

12. The silane abatement system according to Claim 1 further comprising a fusible link within said high pressure pump.

13. The silane abatement system according to Claim 1 further comprising water sprinklers on an upper portion of said outer chamber and over said water-filled chamber.

14. The silane abatement system according to Claim 1 further comprising water sprinklers on surfaces of said exhaust pipe.

15. The silane abatement system according to Claim 1 wherein waste silane gas is abated by:

bubbling silane gas through said silane gas intake pipe and into said water-filled chamber;

5 reacting said silane gas with oxygen dissolved in water in said water-filled chamber whereby SiO_2 precipitates are formed and wherein said SiO_2 precipitates settle to a bottom surface of said water-filled chamber; and

10 opening said valve to drain said SiO_2 precipitates out of said water-filled chamber through said drain.

16. A silane abatement process comprising:

bubbling waste silane gas into a water-filled chamber;

reacting said waste silane gas with oxygen

5 dissolved in water in said water-filled chamber whereby
SiO₂ precipitates are formed and wherein said SiO₂
precipitates settle to a bottom surface of said water-
filled chamber; and

draining said SiO₂ precipitates out of said water-
10 filled chamber.

17. The process according to Claim 16 further comprising
flowing N₂ gas at high pressure to push said waste
silane gas into said water-filled chamber.

18. A silane abatement system comprising:

a water-filled chamber within an outer chamber;

an air intake in one upper portion of said outer
chamber;

5 an exhaust output in another upper portion of said
outer chamber connecting to an exhaust pipe;

water sprinklers on an upper portion of said outer
chamber and over said water-filled chamber and on
surfaces of said exhaust pipe;

10 a silane gas intake pipe running into said outer
chamber and having its output under water in said water-
filled chamber; and

a drain connected through a valve at a bottom
portion of said water-filled chamber.

19. The silane abatement system according to Claim 18 wherein said output of said silane gas intake pipe is into a C-shaped stainless steel pipe having upwardly opening flippers whereby silane gas is released into water within said water-filled chamber.

20. The silane abatement system according to Claim 18 wherein said air intake and said exhaust output both comprise inwardly opening flippers.

21. The silane abatement system according to Claim 18 further comprising an overflow drain at a bottom portion of said outer chamber.

22. The silane abatement system according to Claim 18 further comprising:

a water supply pipe connected to said water-filled chamber;

5 a water level sensor connected to said water-filled chamber;

a water temperature sensor connected to said water-filled chamber;

10 an exhaust temperature sensor connected to said exhaust pipe;

a fusible link within said exhaust pipe; and

a controller that controls said water supply and monitors said water level sensor, said water temperature sensor, said exhaust temperature sensor, and said
15 fusible link.

23. The silane abatement system according to Claim 18 further comprising a high pressure pump connected to said silane gas intake pipe having a fusible link within said high pressure pump.

24. The silane abatement system according to Claim 18 wherein waste silane gas is abated by:

bubbling silane gas through said silane gas intake pipe and into said water-filled chamber;

5 reacting said silane gas with oxygen in water in said water-filled chamber whereby SiO_2 precipitates are formed and wherein said SiO_2 precipitates settle to a bottom surface of said water-filled chamber; and

opening said valve to drain said SiO_2 precipitates
10 out of said water-filled chamber through said drain.

25. The silane abatement system according to Claim 22 wherein in the event that said controller detects an unacceptable condition from any of said water level sensor, said water temperature sensor, said exhaust

temperature sensor, or said fusible link, said water sprinklers are triggered, said air intake and exhaust flippers are closed, and residue waste silane gas within said silane gas intake pipe is pumped into said water-filled chamber.