

Description

The present invention relates to a process for treating waste gases containing ClF_3 . More particularly, the present invention relates to a method by which waste gases that result from the step of dry cleaning the inside surfaces of processing apparatus and related jigs in semiconductor device fabrication with ClF_3 can be rendered harmless by removing not only ClF_3 but also acidic gases including SiCl_4 , SiF_4 , Cl_2 and F_2 .

In order to meet the recent demand for reducing the feature size of VLSIs and improving the efficiency of their fabrication, there has been a growing need for auto-cleaning the inside surfaces of CVD and PVD apparatus as well as related jigs in the fabrication of semiconductor devices. In this respect, the effectiveness of ClF_3 has attracted the attention of manufacturers since it is capable of plasmaless cleaning at low concentrations and temperatures. However, ClF_3 has a very high level of toxicity (TLV-TWA = 0.1 ppm) and it is strongly desired to establish a method of rendering ClF_3 harmless. Common methods for making ClF_3 harmless include wet systems using a scrubber with aqueous alkaline solutions and dry systems using soda lime or activated alumina.

In the prior art, ClF_3 cannot be completely removed by single use of treating agents such as alkali agents or activated alumina. In addition, chlorine oxides are released by reaction with the treating agents used. Further, acidic gases such as SiCl_4 , SiF_4 , Cl_2 and F_2 that are discharged together with ClF_3 can only be partially removed, or they can only be removed in very small amounts.

It is an object of the present invention to provide a process for treating ClF_3 containing gases by which the content of ClF_3 can be reduced below the TLV-TWA level despite simultaneous emission of acidic gases, and yet which is capable of removing the concomitant acidic gases in an effective manner.

Other objects and advantages of the present invention will become apparent to those skilled in the art from the following description and disclosure.

In its first aspect, the present invention attains its object by bringing a waste gas containing ClF_3 into contact with an iron oxide at ordinary temperatures.

In its second aspect, the present invention attains its object by bringing a waste gas containing ClF_3 into contact first with an iron oxide at ordinary temperatures and then with an alkali agent. In this second approach, a waste gas containing not only ClF_3 but also acidic gases such as SiCl_4 , SiF_4 , Cl_2 and F_2 is treated by the present invention in the following specific way: first, the waste gas is brought into contact with an iron oxide at ordinary temperatures so that ClF_3 in the waste gas is fixed as an iron fluoride or chloride on the surface of the iron oxide; secondly, gaseous fluorides and chlorides that are released as by-products are nearly removed by an alkali agent so that the waste gas becomes harmless.

When a waste gas containing ClF_3 is brought into contact with an iron oxide, ClF_3 is fixed as an iron fluoride or chloride on the surface of the iron oxide. An example of the reaction between ClF_3 and iron oxide is represented as follows:



While ClF_3 is fixed as FeF_3 and FeCl_3 on the surface of iron oxide, gaseous fluorides and chlorides are released as, for example, ClO_2 , FO_2 , HCl , HF , etc. These gaseous components are removed by neutralization through contact with the alkali agent. The other acidic gases in the waste gas can be substantially fixed as the iron fluorides and chlorides by mere contact with the iron oxide.

The iron oxide to be used in the present invention may be any ordinary commercial product as long as it is substantially composed of ferric oxide (Fe_2O_3). Further, this iron oxide may be granular, rod-shaped, tabular or in any other form that is easy to handle and it need not be treated or processed in any special way to have a particularly high purity.

The alkali agent to be used in the present invention is preferably at least one alkaline earth metal compound selected from the group consisting of calcium hydroxide, calcium oxide, magnesium hydroxide or magnesium oxide. The shape of this alkali agent also is not limited in any particular way.

On the condition that an undesirably high pressure loss does not occur in the passage of waste gases, the particles of those treating agents are preferably as small as possible, desirably in the range of about 3 - 32 mesh, more desirably about 7 - 16 mesh, in order to ensure a large contact area.

The waste gases need be treated at ordinary temperatures and using elevated temperatures is not economical in view of the need to make the material and construction of the apparatus heat-resistant.

The waste gases are allowed to pass through said treating agents at a linear velocity (LV) of about 10 - 200 cm/min, preferably about 10 - 100 cm/min, to attain contact between said waste gases and said treating agents.

In practice, a column may be packed with two stages of treating agents (iron oxide and alkali agent) in specific amounts that depend on the load of a waste gas to be treated; then, the waste gas is supplied into the column either downwardly or upwardly so that it is brought into contact first with the iron oxide and then

with the alkali agent.

Examples

The following examples are provided for the purpose of further illustrating the present invention but are in no way to be taken as limiting.

Example 1 and Comparative Examples 1 - 3

A polyacrylic vessel (40 mm ϕ) was packed with four different treating agents to a height of 50 mm and supplied with N₂ diluted ClF₃ (1 v/v %) at a flow rate of 0.3 l/min (LV = about 24 cm/min) at ordinary temperatures. In order to monitor the concentration of ClF₃ at the exit end, the concentration of chlorine oxides was measured with a detection tube (produced by Gastec Corporation). The treatment was continued until the concentration of chlorine oxides exceeded the detection limit (0.1 ppm as TLV) and the throughput of ClF₃ treatment was determined from the cumulative volume of ClF₃ and the amount of each treating agent packed. At the same time, the amounts of gaseous fluoride and chloride compounds that evolved as by-products of the treatment at the exit end of the layer of each treating agent were measured by the combination of absorption by alkali solution and ion-exchange chromatography.

The treating agents used were commercial products in a granular form having particle sizes of 7 - 16 mesh. The results are shown in Table 1. When Fe₂O₃ was used as a treating agent, the throughput was the highest (13 l of ClF₃ per liter of treating agent) but fluorides and chlorides were detected as by-products. Comparative treating agents, Al₂O₃, CaO-NaOH and Ca(OH)₂, achieved much lower throughputs with high yields of by-products.

Table 1

	Treating agent	Concentration of ClF ₃ (v/v %)	Throughput of ClF ₃ (l-ClF ₃ /l-treating agent)	Amount of F evolution: total F as ClF ₃ (ppm)	Amount of Cl evolution: total Cl as ClF ₃ (ppm)
Ex. 1	Fe ₂ O ₃	1	13	0.19 - 0.32 (0.26)	0.43 - 0.51 (0.47)
Comp. Ex. 1	Al ₂ O ₃ gel	1	1.3	2.1 - 3.2 (2.6)	2.9 - 4.2 (3.4)
2	CaO-NaOH	1	0.6	4.5 - 6.3 (5.2)	3.7 - 7.1 (5.9)
3	Ca(OH) ₂	1	0	-	-

Note: Numerals in parentheses refer to average values.

Examples 2 - 5

The ability of Fe₂O₃ to treat acidic gases was evaluated using an apparatus of the same type as used in Example 1. The Fe₂O₃ used as the treating agent was also of the same type as in Example 1. Four acidic gases, SiCl₄, SiF₄, Cl₂ and F₂, each (2 v/v %) diluted with N₂ was individually supplied into the apparatus at a flow rate of 0.3 l/min (LV = about 24 cm/min) at ordinary temperatures. The treatment was continued until these gases were detected with a detection tube at the exit end of the apparatus, the detection limit of SiCl₄, SiF₄, Cl₂ and F₂ being 5 ppm as HCl, 3 ppm as HF, 1 ppm and 1 ppm, respectively. Their throughputs were determined from the cumulative volumes of the input gases. The results are shown in Table 2. It was verified that the four acidic gases under test could be removed using Fe₂O₃.

Table 2

	Treating agent	Acidic gas	Gas concentration (v/v %)	Throughput (l/l)
Example 2	Fe ₂ O ₃	SiCl ₄	2	16
3	Fe ₂ O ₃	SiF ₄	2	35
4	Fe ₂ O ₃	Cl ₂	2	3
5	Fe ₂ O ₃	F ₂	2	45

Example 6

A polyacrylic vessel (40 mm⁴) was divided into two stages, one of which was packed with Fe₂O₃ to a height of 200 mm and the other being packed with Ca(OH)₂ to a height of 50 mm. The Fe₂O₃ and Ca(OH)₂ used were of the same types as used in Example 1 and Comparative Example 3, respectively. A N₂ diluted gaseous mixture of ClF₃ and SiF₄ was supplied into the vessel at a flow rate of 0.3 l/min (LV = about 24 cm/min) at ordinary temperatures so that it would first pass through the layer of Fe₂O₃, then through the layer of Ca(OH)₂. The concentrations of ClF₃ and SiF₄ were each 1 v/v % at the entrance to the vessel.

The amounts of discharged chlorine oxide, fluorides and chlorides were measured at the exit end of the Ca(OH)₂ layer. The treatment was continued for 830 minutes and it was verified that those components had been removed to levels below their detection limit (0.1 ppm as ClF₃).

According to the present invention, not only ClF₃ but also concomitant acidic gases can be effectively removed. Further, the treating agents used in the method of the present invention have such a high throughput that they need not be replaced for a prolonged period of time.

Claims

1. A process for treating waste gases containing ClF₃ by bringing the gases into contact with an iron oxide substantially composed of ferric oxide (Fe₂O₃) at a linear velocity of about 10 - 200 cm/min at a ordinary temperature.
2. A process according to Claim 1 in which said gas is subsequently contacted with an alkali agent at a linear velocity of about 10 - 200 cm/min at ordinary temperatures, said alkali agent comprising at least one alkaline earth metal compound selected from the group consisting of calcium hydroxide, calcium oxide, magnesium hydroxide and magnesium oxide.
3. A process according to Claim 1 or 2 wherein said each linear velocity is about 10 - 100 cm/min.
4. A process according to Claim 1 or 2 wherein said each linear velocity is about 24 cm/min.

Patentansprüche

1. Verfahren zum Behandeln von ClF₃ enthaltenden Abgasen durch Inkontaktbringen der Gase mit einem Eisenoxid, das im wesentlichen aus Eisen(III)-oxid besteht, bei einer linearen Geschwindigkeit von etwa 10 - 200 cm/min bei normaler Temperatur.
2. Verfahren nach Anspruch 1, bei dem das Gas nachfolgend bei einer linearen Geschwindigkeit von etwa 10 - 200 cm/min bei normalen Temperaturen mit einem alkalischen Mittel in Kontakt gebracht wird, wobei das alkalische Mittel mindestens eine Erdalkalimetallverbindung enthält, die ausgewählt ist aus der Gruppe bestehend aus Calciumhydroxid, Calciumoxid, Magnesiumhydroxid und Magnesiumoxid.

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3. Verfahren nach Anspruch 1 oder 2, bei dem jede der linearen Geschwindigkeiten etwa 10 - 100 cm/min beträgt.
- 5 4. Verfahren nach Anspruch 1 oder 2, bei dem jede der linearen Geschwindigkeiten etwa 24 cm/min beträgt.

Revendications

- 10 1. Procédé de traitement de gaz résiduels contenant ClF_3 , en mettant les gaz en contact avec un oxyde de fer, comprenant principalement de l'oxyde ferrique (Fe_2O_3) selon une vitesse linéaire d'environ 10 à 200 cm/mn à température ordinaire.
- 15 2. Procédé selon la revendication, dans lequel le gaz est ensuite mis en contact avec un agent alcalin selon une vitesse linéaire d'environ 10 à 200 cm/mn, à des températures ordinaires, cet agent alcalin comprenant au moins un composé de métal alcalino-terreux choisi parmi l'hydroxyde de calcium, l'oxyde de calcium, l'hydroxyde de magnésium et l'oxyde de magnésium.
- 20 3. Procédé selon la revendication 1 ou 2, dans lequel chaque vitesse linéaire est d'environ 10 à 100 cm/mn.
- 20 4. Procédé selon la revendication 1 ou 2, dans lequel chaque vitesse linéaire est d'environ 24 cm/mn.

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