

DESCRIPTION

CLEANING GAS FOR SEMICONDUCTOR PRODUCTION EQUIPMENT AND
CLEANING METHOD USING THE GAS

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CROSS-REFERENCE TO RELATED APPLICATIONS

This is an application filed pursuant to 35 U.S.C.
Section 111(a) with claiming the benefit of U.S.
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111(b), pursuant to 35 U.S.C. Section 119(e)(1).

TECHNICAL FIELD

The present invention relates to a cleaning gas for
15 equipment for producing semiconductors or TFT (thin film
transistor) liquid crystal devices, a cleaning method
using the gas, wherein unnecessary deposits accumulated
inside film-forming equipment or etching equipment at the
time of film formation or etching of silicon, silicon
20 nitride, silicon oxide, tungsten and the like are removed,
and also to a method for producing a semiconductor device
including the cleaning step using the cleaning gas.

BACKGROUND ART

25 In the film-forming equipment or etching equipment
for production of semiconductor or TFT liquid crystal
device, deposits accumulated at the film-formation or
etching of silicon, silicon nitride, silicon oxide,
tungsten and the like cause generation of particles and
30 hinder production of good film, therefore, these deposits
must be removed on occasion.

Heretofore, deposits in semiconductor production
equipment are removed by a method of etching the deposits

using a plasma excited from a fluorine-type etching gas such as NF_3 , CF_4 and C_2F_6 . However, method of using NF_3 has a problem in that the NF_3 is expensive, and method of using perfluorocarbon such as CF_4 and C_2F_6 has a problem
5 in that the etching rate is low and the cleaning efficiency is low. Furthermore, etching methods using a etching gas such as perfluorocarbon involves emission of a large amount of unreacted gas, requiring a burden of post process of eliminating pollutional discharges and
10 causing a problem of a high burden on the environment due to emission of greenhouse gas.

On the other hand, as a technique for increasing cleaning efficiency, method of adding O_2 to perfluorocarbon such as CF_4 and C_2F_6 is being employed,
15 however, it is also known that excessive addition of O_2 adversely reduces cleaning efficiency. It is presumed that addition of O_2 has effects of making fluorine readily released by (1) generating CO_x or SO_x by reacting carbon or sulfur dissociated during excitation, and (2)
20 suppressing formation and re-formation of C-C bond or S-S bond. Though interaction between F and O is weak as compared with those between C and O or S and O, an excessive amount of oxygen(O) accelerates deactivation of F radicals.

25 An advantage in using F_2 gas as a cleaning gas is that process of eliminating pollutional discharges is easy. Conventional cleaning method using gases such as perfluorocarbon, and NF_3 , in view of energy required, costs a lot in eliminating unreacted gas discharged in a
30 large amount, whereas a cleaning method using F_2 is cost-effective because of its high reactivity which enables easy elimination of pollutional discharges by a conventional process generally employed.

Since process of removing deposits is based on reaction between fluorine and the deposits, if the gas to be introduced is pure fluorine, theoretically, the cleaning efficiency will exhibit the highest value.

5 However, purity of fluorine gases commercially available at present is low, and impurities such as HF, O₂, N₂, CO₂, H₂O, CF₄ and SF₆ are contained therein. O₂, CO₂, and H₂O are likely to adversely affect cleaning process using F₂ gas, though HF can be relatively easily removed
10 by adsorption operation and N₂, CF₄ and SF₆, which are employable as a diluting gas or an etching gas, have little adverse effects on cleaning process using F₂ gas.

DISCLOSURE OF INVENTION

15 The present invention has been made under these circumstances. Accordingly, one of the objects of the present invention is to provide a cleaning gas and a cleaning method using the gas, which ensure high etching rate, high cleaning efficiency and excellent cost
20 performance. Furthermore, another one of the objects of the present invention is to provide a method for producing a semiconductor device.

As a result of extensive investigations to solve the above-described problems, the present inventors have
25 found that a cleaning gas comprising fluorine wherein content of oxygen and/or oxygen-containing compounds is extremely reduced enhances etching rate and improves cleaning efficiency, to thereby complete the invention.

That is, the present invention relates to a cleaning
30 gas and a cleaning method and to a method for producing a semiconductor device, as described in (1) and (16) below.

(1) A cleaning gas for removing deposits in

equipment for producing semiconductor or liquid crystal, comprising fluorine gas containing 1 vol% or less of oxygen and/or oxygen-containing compound.

(2) The cleaning gas as described in (1) above,
5 wherein the content of oxygen and/or oxygen-containing compound contained in the fluorine gas is 0.5 vol% or less.

(3) The cleaning gas as described in (2) above,
10 wherein the content of oxygen and/or oxygen-containing compound contained in the fluorine gas is 0.1 vol% or less.

(4) The cleaning gas as described in any one of (1) to (3) above, wherein purity of the fluorine gas is 99 vol% or more.

15 (5) The cleaning gas as described in (4) above, wherein purity of the fluorine gas is 99.5 vol% or more.

(6) The cleaning gas as described in any one of (1) to (3) above, wherein the oxygen-containing compound is at least one compound selected from a group consisting of
20 NO, N₂O, NO₂, CO, CO₂, H₂O, OF₂, O₂F₂ and O₃F₂.

(7) The cleaning gas as described in (6) above, wherein the oxygen-containing compound is at least one compound selected from a group consisting of CO, CO₂ and H₂O.

25 (8) The cleaning gas as described in any one of (1) to (7) above, comprising at least one diluting gas selected from a group consisting of He, Ar, N₂, Ne, Kr and Xe.

(9) The cleaning gas as described in (8) above,
30 comprising at least one diluting gas selected from a group consisting of He, Ar and N₂.

(10) A method for cleaning production equipment of semiconductors or liquid crystal devices, using the

cleaning gas as described in any one of (1) to (9) above.

(11) The cleaning method as described in (10) above, wherein the cleaning gas described in any one of (1) to (9) above is excited to produce plasma and the deposits
5 in the semiconductor production equipment are removed in the plasma.

(12) The cleaning method as described in (11) above, wherein the excitation source for the plasma is a microwave.

10 (13) The cleaning method as described in (10) above, wherein the cleaning gas is used at a temperature range of 50 to 500°C.

(14) The cleaning method as described in (10) above, wherein the cleaning gas is used at a temperature range
15 of 200 to 500°C in a plasmaless system.

(15) A method for producing a semiconductor device, comprising a cleaning step of using the cleaning gas as described in any one of (1) to (9) above and a decomposition step of decomposing a fluoro compound-
20 containing gas discharged from the cleaning step.

(16) The method for producing a semiconductor device as described in (15) above, wherein the fluoro compound is at least one compound selected from a group consisting of SiF₄, HF, CF₄, NF₃ and WF₆.

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BRIEF DESCRIPTION OF DRAWING

Fig. 1 is a schematic view of etching equipment using the cleaning gas of the present invention.

30 DETAILED DESCRIPTION OF INVENTION

The present invention is described in detail below.

The cleaning gas for production equipment for semiconductor or liquid crystal devices of the present

invention comprises a fluorine gas containing 1 vol% or less of oxygen and/or oxygen-containing compounds.

In the cleaning gas for production equipment for semiconductor, the content of oxygen and/or oxygen-containing compounds contained in the fluorine gas is preferably 0.5 vol% or less, more preferably 0.1 vol% or less. If the content of oxygen and/or oxygen-containing compounds in the fluorine gas exceeds 1 vol%, cleaning efficiency is unpreferably reduced.

10 The oxygen-containing compound is, for example, one or more compounds selected from a group consisting of NO, N₂O, NO₂, CO, CO₂, H₂O, OF₂, O₂F₂ and O₃F₂, and the cleaning gas of the present invention is characterized in comprising fluorine gas containing oxygen and/or oxygen-containing compound at 1 vol% or less. The oxygen-containing compound may be one or more compounds selected from a group consisting of CO, CO₂ and H₂O.

Purity of fluorine gas, determined by eliminating oxygen and/or oxygen-containing compound contained therein as impurities, is preferably 99 vol% or more, more preferably 99.5 vol% or more. Further, though the cleaning gas of the present invention contains fluorine gas having 1 vol% or less of oxygen and/or oxygen-containing compound preferably without diluting the fluorine gas, the fluorine gas may be diluted if necessary under some cleaning conditions. Gas for diluting the fluorine gas is preferably at least a diluting gas selected from a group consisting of He, Ar, N₂, Ne, Kr and Xe, more preferably at least a diluting gas selected from a group consisting of He, Ar and N₂.

In the case of cleaning semiconductor production equipment using the cleaning gas of the present invention, the gas may be used under the plasma condition or under

the plasmaless condition.

When the gas is used under the plasma condition, the excitation source is not particularly limited as long as plasma is excited from the cleaning gas of the present invention, but a microwave excitation source is preferred because good cleaning efficiency can be attained. Also, the temperature and the pressure when the cleaning gas of the present invention is used are not particularly limited as long as plasma can be produced, but the temperature range is preferably from 50 to 500°C and the pressure range is preferably from 1 to 500 Pa.

In the case of plasmaless condition, the cleaning gas is introduced into a chamber, the inner pressure of the chamber is preferably set to 1 to 500Pa and at least a part of or either one of the inside of chamber and the cleaning gas is heated at 200 to 500°C to activate the cleaning gas. Then, deposits are etched and removed from the chamber and from other regions where deposits are accumulated, and thereby the semiconductor production equipment can be cleaned.

In the cleaning gas for semiconductor production equipment of the present invention,

(1) F_2 gas capable of dissociating at a low energy level and producing an active species is contained in the gas, and

(2) the content of oxygen and/or oxygen-containing compound contained therein, which have adverse effects on generation and sustainment of fluorine free radicals, is reduced to the minimum. By these features, the present invention exhibits more advantageous effects than conventionally used NF_3 gas. As compared to NF_3 gas, F_2 dissociates at a low energy level and at the time of complete dissociation, produces only F radicals.

Therefore, since it is only active species which exists in the system when cleaning is performed, reaction efficiency with deposits accumulated therein is extremely high.

5 Fig. 1 is a view showing one example of the etching equipment using the cleaning gas of the present invention. The cleaning gas is introduced into a chamber 1 set at a constant temperature from a cleaning gas inlet 6 and at this time, the gas is excited by a microwave plasma
10 excitation source 4 and produces plasma. The gas obtained after the etching of a silicon wafer 2 on sample stage 3 is discharged by a dry pump 5 and rendered harmless using a decomposing agent according to the kind of the gases contained therein. Furthermore, the
15 deposits accumulated after the etching are efficiently removed by repeating the same operation as the etching, and thereby the chamber can be efficiently cleaned.

Next, production process for semiconductor device of the present invention will be described.

20 As aforementioned, according to the present invention, cleaning of semiconductor production equipment can be efficiently performed. However, gas discharged during the cleaning process using the cleaning gas of the present invention contains, in addition to F_2 gas used
25 for cleaning, fluoro compounds such as HF , CF_4 , SiF_4 , NF_3 and WF_6 . These compounds, containing F_2 , which greatly affect global warming if released to the atmosphere as they are or generate acidic gas if decomposed, need to be rendered completely harmless. The present invention
30 provides a production process for semiconductor device comprising a cleaning step of semiconductor production equipment and a decomposition step of decomposing a fluoro compound-containing gas discharged from the

cleaning step in a production process for semiconductor device.

A cleaning step of semiconductor production equipment can be performed using the aforementioned method. Moreover, method employed in a decomposing step of gas containing fluoro compound discharged from the cleaning step is not particularly limited and decomposing agent may be selected according to the kind of compound contained in the discharged gas. Preferably, hydrogen fluoride is released after stabilized as a metal fluoride and carbon is released after decomposed to be carbon dioxide.

BEST MODE FOR CARRYING OUT INVENTION

The present invention is described in greater detail below by referring to the Examples and Comparative Example, however, the present invention is not limited to these Examples.

Examples 1 to 2

A testing apparatus shown in Fig. 1 was adjusted to an apparatus inner pressure of 300 Pa. A cleaning gas having the composition shown in Table 1 was excited by a microwave plasma excitation source of 2.45 GHz and 500 W and then introduced into the testing apparatus to etch a silicon wafer placed in the testing apparatus. The etching rate was determined from the loss in volume of the silicon wafer after etching and the results are shown in Table 1.

Table 1

Example	Gas Used and Mixing Ratio (Volume %)		Etching Rate (nm/min)
	F ₂	O ₂	
1	100	0	2000
2	99	1	1800

It is revealed that F₂ gas containing 1 vol% or less
 5 of oxygen exhibited a remarkably high etching rate.

Comparative Example 1

The etching rate of each cleaning gas was determined
 in the same manner as in Example 1 except that the
 10 cleaning gas was changed to a gas having composition
 shown in Table 2.

Table 2

Comparative Example	Gas Used and Mixing Ratio (Volume Ratio)		Etching Rate (nm/min)
	F ₂	O ₂	
1	95	5	1200

15 It is revealed that the etching rate was greatly
 reduced when F₂ gas contained 5 vol% or more of oxygen.

Example 3

In place of a silicon wafer, a quartz piece having
 20 accumulated thereon deposits of amorphous silicon,
 silicon nitride and the like was subjected to cleaning.

The cleaning gas as used in Example 1 was excited by a microwave plasma excitation source of 2.45 GHz and 500 W and introduced into a chamber of a testing apparatus adjusted to an inner pressure of 300 Pa, and the quartz
5 piece was cleaned and then taken out. As a result, it was confirmed that the deposits were completely removed.

INDUSTRIAL APPLICABILITY

The cleaning gas for semiconductor production
10 equipment of the present invention is high in the etching rate, therefore, ensures efficient cleaning and excellent cost performance. According to the method for cleaning semiconductor production equipment of the present invention, unnecessary deposits in the film-forming
15 equipment or etching equipment for the production of a semiconductor or a TFT liquid crystal element accumulated at the time of film-formation or etching of silicon, silicon nitride, silicon oxide, tungsten or the like can be efficiently removed. Furthermore, by using the method
20 comprising a cleaning step of using the cleaning gas of the present invention and a step of decomposing and thereby rendering harmless the fluoro compound-containing exhaust gas discharged from the cleaning step, a semiconductor device can be efficiently produced.

25

CLAIMS

1. A method for cleaning production equipment of semiconductors or liquid crystal devices using a cleaning gas for removing deposits in the equipment under a pressure of 1 to 500 Pa, comprising (a) exciting the cleaning gas to produce plasma by using a microwave and then removing the deposits in the plasma at a temperature range of 50 to 500°C, or (b) removing the deposits in a plasmaless system at a temperature range of 200 to 500°C, wherein the cleaning gas comprises fluorine gas containing 1 vol% or less of oxygen and / or oxygen-containing compound.
2. A method for producing a semiconductor device, comprising a cleaning step as described in claim 1 and a decomposition step of decomposing a fluoro compound-containing gas discharged from the cleaning step.
3. The method for producing a semiconductor device as claimed in claim 2, wherein the fluoro compound is at least one compound selected from a group consisting of SiF_4 , HF, CF_4 , NF_3 and WF_6 .