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(54) Method for plasma etching a semiconductor device

(57) The method seeks to improve the etched profiles by mixing various gases with a main etching gas and supplying the mixture to form a thin passivation layer 18 made of a polymer on a sidewall of a profile etched in a layer 14 on a substrate 10.

The method comprises supplying a mixture of an etching gas containing chlorine or fluorine and an additional gas such as bromomethane which generates an intermediate having a carbene structure by plasma discharge, forming a polymer which is a combination of the intermediate with the material of the layer 14, on the side walls of profiles etched in the layer.

FIG. 2

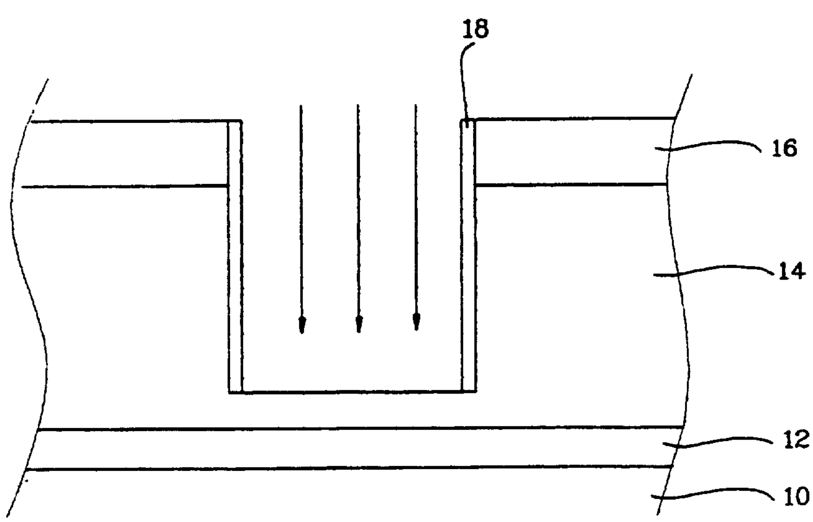

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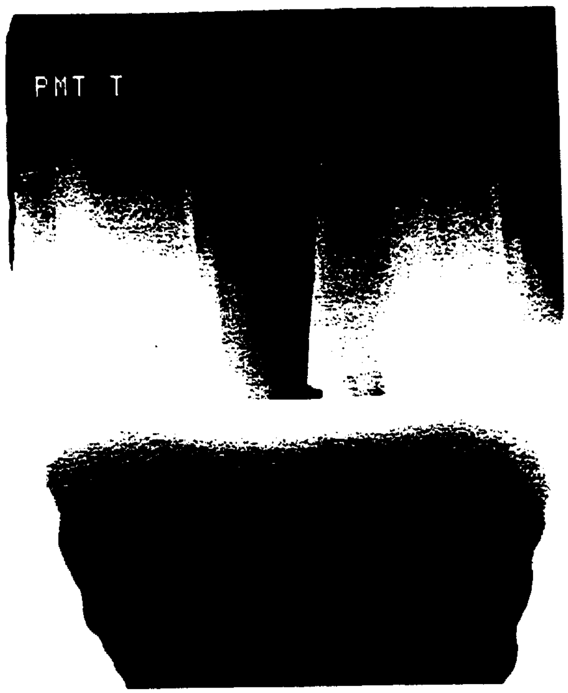
FIG. 1

(A)



(B)

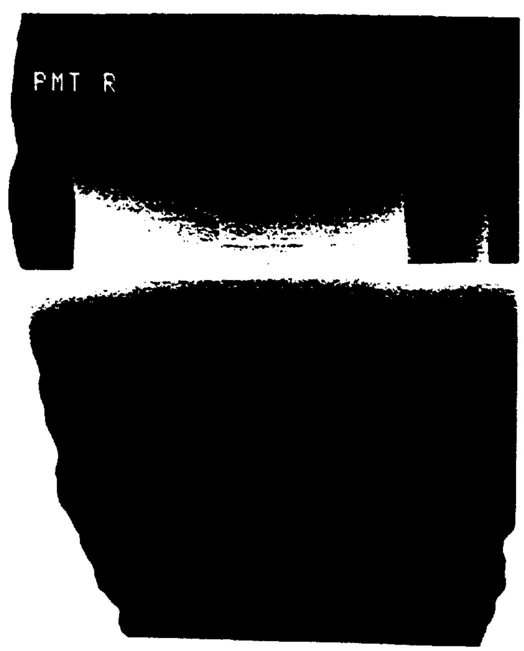


FIG. 2

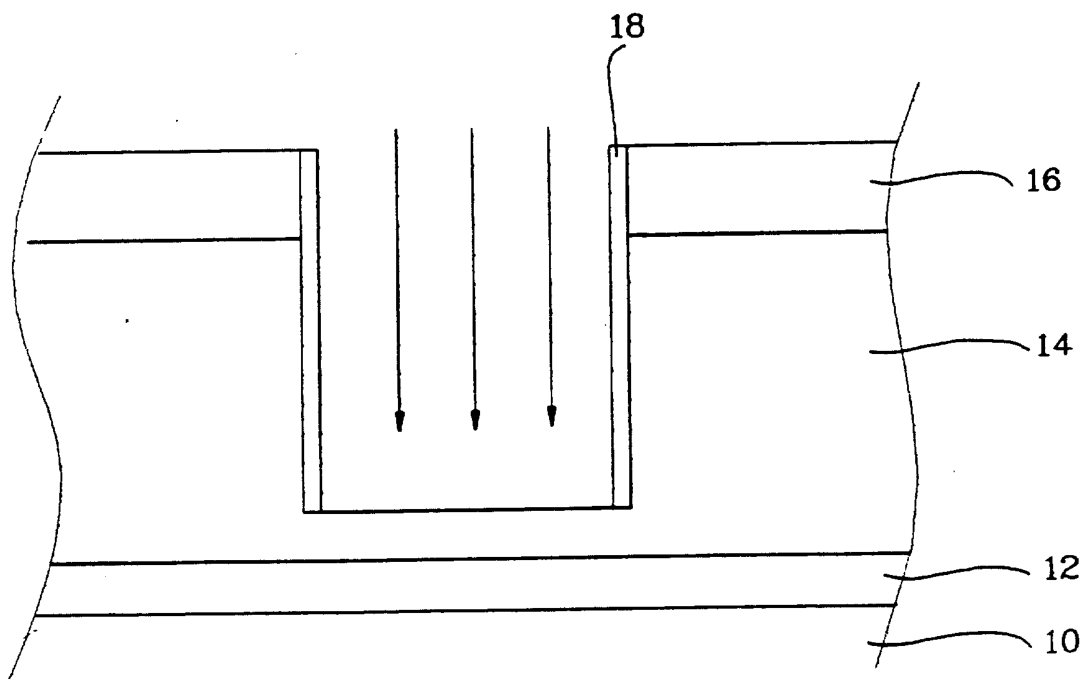


FIG. 3

(A)

(B)

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METHOD FOR PLASMA ETCHING IN A PROCESS FOR FABRICATION OF SEMICONDUCTOR DEVICE

FIELD OF THE INVENTION

The present invention relates to a method for plasma etching in a process for fabrication of a semiconductor device. More specifically, it relates to a method for plasma etching in a process for fabrication of a semiconductor device for improving the profiles by mixing additional various gases to a main etching gas and supplying the mixture to form a thin layer made of a polymer for passivation on a sidewall of the portion of which the layer of wafer is to be selectively etched.

BACKGROUND OF THE INVENTION

As semiconductor industry is highly developed, semiconductor devices requires high capacity and high function, and thus integration of more elements in a restricted area is required, and the techniques of wafer processing is researched and developed for achieving ultra-fine and highly-integrated pattern.

In a process for fabrication of wafer for achieving a ultra-fine and highly-integrated semiconductor device, dry etching techniques have been widely used and plasma fusion etching method is most generally used as a dry etching technique.

However, a etching process using plasma is a very important but difficult technique, and the details considered primarily in plasma etching process are etching profiles, selectivity with a lower layer, etch rate and uniformity. These depend chiefly on the characteristics of etching apparatuses or supplied gases and specifically, uniformity is very influenced by characteristics of etching apparatuses and other three details are influenced by characteristics of supplied gases.

Recently, techniques for improving the profiles by adding gas forming a polymer to supplied gas and performing plasma etching process with gas mixture to achieve ultra-fine and highly-integrated pattern have been developed. Such techniques for improving the profiles are described in "VLSI Technology"(S.M. Sze, 2nd edition, McGraw Hill Press, 1988, pp200-204) and U.S. Patent No.4,490,209.

Namely, when a layer of a silicon-bearing material is etched with conventional plasma etching method, halogen compound containing fluorine(F) and chlorine(Cl) is supplied as a main etching gas according to the properties of a layer and as a usage for improving the etching profiles of a layer and selectivity with a lower layer or as a usage for carrier, other gases are supplied to a main etching gas by mixing.

The gases supplied by mixing have respectively predetermined roles. Because inactive gas such as helium(He) and argon(Ar) has a relatively heavy mass, such gases play a role as a carrier for a main etching gas and also performs a role in etching a layer by physical sputtering. Oxygen(O_2) and nitrogen(N_2) are present as O, N in radical state or O_2^+, N_2^+ in ion state by plasma discharge and play roles in controlling profiles by increasing or decreasing polymers generated in etched portion.

And after hydrogen bromide(HBr) is dissociated in plasma, bromine is adsorbed on a sidewall of etched portion and forms a polymer of Si-Br line. Such a polymer of Si-Br line acts as a passivation for formation of good profiles by interrupting the reaction of the surface of sidewall of etched layer with chlorine.

The results of which polysilicon layer is etched by methods using a mixed gas of typical chlorine, hydrogen bromide, oxygen and argon as mentioned above are illustrated in FIGs. 1(a) and 1(b).

In FIG. 1, the appearance of etched profiles of polysilicon layer is approximately a form of reverse-trapezoid and the etched perpendicular plane is formed as being tilted.

Therefore, because above conventional plasma etching methods cannot provide the profiles for the etched sidewall of layer with satisfactory perpendicularity, the conventional methods cannot be applied to a process requiring ultra-fine and high integration.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a method for plasma etching in a process for fabrication of a semiconductor device for improving the appearance of the profile of which a specific layer have been etched to be suitable for a process which requires ultra-fine and high integration.

Another object of the present invention is to provide a method for plasma etching in a process for fabrication of a semiconductor device for improving the appearance of the profile etched on the layer by mixing a gas generating an intermediate of carbene structure due to the dissociation in plasma state, with a main etching gas containing fluorine or chlorine, and supplying the mixed gas, in the etching of silicon-bearing layer.

Another object of the present invention is to provide a method for plasma etching in a process for fabrication of a semiconductor device for improving the appearance of the profile etched on the layer by mixing additional gases to which bromine or other halogen is bonded, with an etching gas containing fluorine or chlorine, and supplying the mixed gas, in the etching of silicon-bearing layer.

Another object of the present invention is to provide a method for plasma etching in a process for fabrication of a semiconductor device for improving the appearance of the profile etched on the layer by mixing boron tribromide gas with an etching gas containing fluorine or chlorine, and supplying the mixed gas, in the etching of silicon-bearing layer.

Still another object of the present invention is to provide a method for plasma etching in a process for fabrication of a semiconductor device for improving the appearance of the profile etched on the layer by mixing a gas generating an intermediate of carbene structure due to the dissociation in plasma state, with a main etching gas, and supplying the mixed gas, in the etching of metal layer.

In order to achieve the above objects, the present invention provides a method for plasma etching in a process for fabrication of a semiconductor device, in which a plurality of supplying gases are converted to plasma state to etch the polysilicon layer on a wafer by a selective reaction and ion collision depending on the pattern masked on the upper part, characterized in that the method comprises a step of supplying a mixed gas of an etching gas containing chlorine or fluorine and an additional gas which generates an intermediate of carbene structure by plasma discharge, as the supplying gas; and a step of forming a polymer generated in plasma state, which is a combined material of the intermediate, on the side walls of profiles of which the polysilicon layer is etched.

As the etching gas, Cl_2, BCl, HCl, $SiCl_4$, F_2, SF_6, CF_4

, CHF_3 or a mixture thereof may be used, while as the additional gas, CH_3Br, CH_2Br_2, $CHBr_3$, C_2H_5Br, $C_2H_4Br_2$ or a mixture thereof may be used.

In addition, if the lower layer of the polysilicon is made of silicon oxide (SiO_2), more oxygen is supplied for etching selectivity between the layers. The ratio of chlorine to oxygen is preferably 2:1 to 6:1.

The etching gas and the additional gas may generate intermediates as inductively coupled plasma or capacitively coupled plasma to selectively etch the polysilicon layer.

The present invention also provides a method for plasma etching in a process for preparation of a semiconductor device, in which a plurality of supplying gases are converted to plasma state to etch the silicon oxide layer on a wafer by a selective reaction and ion collision depending on the pattern masked on the upper part, characterized in that the method comprises a step of supplying a mixed gas of an etching gas containing fluorine and an additional gas which generates an intermediate of carbene structure by plasma discharge, as the supplying gas; and a step of forming a polymer generated in plasma state, which is a combined material of the intermediate, on the side walls of profiles of which the silicon oxide layer is etched.

As the etching gas, F_2, SF_6, CF_4 or CHF_3 may be preferably used.

Also, the present invention provides a method for plasma etching in a process for fabrication of semiconductor device for etching of a silicon-bearing material on a wafer, wherein BrI or Br_2 (in which bromine and other halogen atom are bonded) is supplied with an etching gas to form a polymer for protecting the sidewalls of profiles formed by selective etching of the silicon-bearing layer.

Further, the present invention provides a method for plasma etching in a process for fabrication of a semiconductor device, in which a plurality of supplying gases are converted to plasma state to etch the silicon-bearing layer on a wafer by a selective reaction and ion collision depending on the pattern masked on the upper part, wherein the etching gas and boron tribromide are supplied as the supplying gas, whereby the polymer is formed on the sidewalls of profiles of which the silicon-bearing layer is etched by bromine and boron bromide generated from the plasma discharge.

Besides, the present invention provides a method for plasma etching in a process for fabrication of a semiconductor device, in which a plurality of supplying gases are converted to plasma state to etch the metal layer on a wafer by a selective reaction and ion collision depending on the pattern masked on the upper part, characterized in that the method comprises a step of supplying a mixed gas of an etching gas and an additional gas which generates an intermediate of carbene structure by plasma discharge, as the supplying gas; and a step of forming a polymer generated in plasma state, which is a combined material of the intermediate, on the side walls of profiles of which the metal layer is etched.

Embodiments of the invention will now be described by way of example and with reference to the accompanying drawings in which:-

Figures 1(a) and 1(b) are photographs for showing the profiles according to the etching of a layer of a silicon-bearing material by a method of plasma etching in a conventional process for fabrication of semiconductor device.

Figure 2 is a sectional-view of wafer layer for explaining embodiment of a method for plasma etching in a process for fabrication of semiconductor device according to the present invention.

Figures 3(a) and 3(b) are photographs for showing the profiles according to the etching of a layer of silicon-bearing material by embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

According to the present invention, etching is performed on a specific layer formed onto a wafer and the specific layer contains a layer of a silicon-bearing material and a layer of metal material, and a layer of a silicon-bearing material contains a polysilicon layer and a silicon oxide layer.

For etching above-mentioned layers, respective embodiments are accomplished by properly selecting a main etching gas and an additional gases mixed thereto according to the characteristics of each layers.

At first, one embodiment applied to a polysilicon layer will be described with reference to FIG. 2.

Referring to FIG. 2, a base layer(10), a silicon oxide layer(12), a polysilicon layer(14) and a photoresist layer for masking(16) are laminated in order in a wafer.

The base plate(10) is a monocrystal silicon component constituting the wafer and the silicon oxide layer(12) is formed with several hundred Å onto base layer(10) and the polysilicon layer(14) is deposited with several thousand Å to form a gate for transistor, and the photoresist layer(16) is coated for masking the non-etched portion of polysilicon layer(14).

And as apparatuses for performing the etching process in regard to the wafer having laminated structure as shown in FIG.2, a inductively coupled plasma type wherein plasma is inductively generated by winding the coils around the quartz tube(figure not shown) as a plasma source may be used, or a capacitively coupled plasma type in condensing manner may be used. When inductively coupled plasma type is used, a diffuser wherein several sheets of layers are overlapped is equipped before reactor(figure not shown) for uniform mixing of the etching gas. And electricity applied for plasma generation or formation of direct current bias uses radio frequency. The temperature condition is variably determined in a range suitable to characteristics of gases used.

As mentioned above, after setting the environment of apparatuses for plasma etching, a main etching gas is supplied by selecting one from a group consisting of Cl_2, BCl, HCl or $SiCl_4$ comprising chlorine, and bromomethane(CH_3-Br) among gases generating carbene structure intermediate by plasma discharge, namely CH_3Br, CH_2Br_2, $CHBr_3$, C_2H_5Br or $C_2H_4Br_2$, is supplied as an additional gas. The reason for selecting bromomethane among gases generating such carbene structure intermediates is that using gas present in gaseous state at room temperature(about 20°C) is easy to control parameters such as vapor pressure. And other gases generating carbene structure intermediates are selectively used by varying temperature condition.

In addition, oxygen(or nitrogen) is supplied as other additional gas to control the profiles, and argon between inactive gases(Ar or He) is supplied as a carrier usage. Although etching is progressed by supplying F_2, SF_6, CF_4 or CHF_3 comprising fluorine as a main etching gas in regard to polysilicon layer(14), the etching reaction in the condition wherein a main etching gas comprising chlorine is supplied will be described as one embodiment.

Each gases mentioned above(main etching gas, Cl_2,

CH_3Br, O_2 and Ar etc.) is supplied and then converted to intermediate in plasma state by applied radio frequency, and the mechanism is same that the equations described below.

$$Cl_2 \xrightarrow{Rf} Cl + Cl_2^{+} + \text{the others}$$ <Equation 1>

$$CH_3Br \xrightarrow{Rf} Br + C_xH_yBr_z + \text{the others}$$ <Equation 2>

(wherein, x is 0 or 1, y and z are respectively 0 to 2, and Rf means radio frequency)

$$O_2 \xrightarrow{Rf} O + O_2^{+} + \text{the others}$$ <Equation 3>

In addition to above <Equation 1> to <Equation 3>, inactive gas is dissociated and activated.

As mentioned above, components activated in plasma state react with surface of polysilicon layer(14) which is not masked by photoresist layer(16) same as in following Equations. Namely,

$$Cl (\text{or } Cl_2^{+}) + \text{surface Si of polysilicon layer} \longrightarrow SiCl$$ <Equation 4>

$$Br + \text{surface Si of polysilicon layer} \longrightarrow SiBr$$ <Equation 5>

$$C_xH_yBr_z + \text{surface Si of polysilicon layer} \longrightarrow \text{polymer chain}$$ <Equation 6>

Activated chlorine as in <Equation 1> is moved toward the surface of polysilicon layer(14) by being loaded in argon as a carrier gas and bonded to silicon components contained in the surface of polysilicon layer(14) as in <Equation 4> to generate silicon chloride(SiCl) and silicon chloride is deposited onto the surface of polysilicon layer(14).

And bromine generated in the plasma state as in <Equation 2> is bonded to silicon component contained in the surface of polysilicon layer(14) to form SiBr polymer and SiBr polymer is deposited onto the surface as in <Equation 5>.

Also, $C_xH_yBr_z$ generated in <Equation 2> is a carbene having H-C-Br structure and bonded to silicon component contained in the surface of polysilicon layer(14) as in <Equation 6>. Thus, polymer bonded in chain pattern, namely $C_xH_yBr_z$ -$C_xH_yBr_z$ bond is present on the surface and the sidewall of the profiles formed by etching.

In this case, carbene, $C_xH_yBr_z$ wherein each composing elements are combined in ratio of x:y:z, is formed with variation within range that x is 0 and 1, and y and z are 0 to 2. Considering such ratio, hydrogen bromide carbene (:CHBr) and dihydrogen carbene (:CH_2) and dibromocarbene (:CBr_2) are respectively generated and can form the polymer.

That is, polysilicon layer(14) of the wafer is etched in appearance as in FIG. 3 by the formation of SiCl and SiBr generated by the process mentioned above and as polysilicon layer is being etched, SiBr and $C_xH_yBr_z$ -$C_xH_yBr_z$

are adsorbed or formed as a polymer onto the surface being etched.

Polymers can be formed onto the surface of the profiles of polysilicon layer(14), namely sidewall or bottom. Polymers(18) formed onto the sidewall enable the profiles of the sidewall to have perpendicularity by interrupting the reaction of silicon contained in the surface of polysilicon layer(14) with chlorine in plasma state, and as perpendicularity of the sidewall of the profiles are confirmed by polymers(18), over-etching of the sidewall or etching to abnormal profiles can be prevented. But polymers formed onto the bottom act as an element to prevent etching by interrupting the reaction of silicon contained in the surface of polysilicon layer(14) with chlorine in plasma state. However, polymers of the bottom cannot influence the progress of etching because these polymers are removed by physical sputtering with activated argon.

As in above-described process, during the process for progressing the etching, physical sputtering of argon for plasma etching is attained not only in polysilicon layer(14) but also in the surface of photoresist layer(16) for masking. At this time, carbon component is contained in the photoresist and carbon component is diffused by physical sputtering of argon.

Because carbon has an affinity with oxygen, when lower portion of polysilicon layer(14) is composed of silicon oxide layer(12) as in FIG. 2, carbon tends to bind with oxygen contained in silicon oxide layer(12), which is lower layer of polysilicon(14), according to the degree of etching.

Hence, when oxygen of silicon oxide is bonded to carbon, etching becomes to occur in regard to silicon oxide layer(12) and selectivity of etching between layers will be deteriorated. In embodiment according to the present invention, oxygen gas is supplied to prevent thereof. Then, oxygen becomes to plasma state and converted to radical state(O) or ion state(O_2^+) and these are bonded to carbon to become carbon monoxide(CO) and carbon dioxide(CO_2).

Therefore, supply of oxygen gas or nitrogen gas can prevent the deterioration of selectivity between layers due to the carbon component generated during etching process.

However, if amount of oxygen gas is too much compared to that of chlorine gas, rather etching will not be performed and so amount of oxygen gas has to be supplied in appropriate level. It is preferable to be supplied that the ratio of amount of oxygen gas to chlorine gas, which is a main etching gas, is about 2:1 to 6:1.

The results of above one embodiment of the present invention actually tested are shown in FIGs. 3(a) and 3(b).

The test condition is that Cl_2 is supplied as a main etching gas, and CH_3Br, O_2 and inactive gas are used by mixing as an additional gas. The condition for etching apparatuses is determined to be that electricity is 800 - 1000W, bias power is 0 -300W and total pressure is 2 -15mT. Also, the amounts of each gases supplied are controlled and then supplied so as to be that Cl_2 is 10 - 200sccm, CH_3Br is 2 - 100sccm, O_2 is 0 - 100sccm and inactive gas is 0 - 200sccm.

The unit of gas supply, sccm, is a unit that represents the amount of fluid supplied for 1 minute(standard cubic centimeter per minute) at 0°C, 1 atm. And the temperature of electrode for controlling the temperature of the inside wherein etching is performed is determined to be -20 - 60 °C.

When the profiles in FIGs. 3(a) and 3(b) which are results of experiment under above condition are compared to the profiles in FIGs. 1(a) and 1(b) etched according to the conventional method, in profiles in FIGs. 3(a) and 3(b) according to the one embodiment of the present invention, boundary plane between photoresist layer(16) and polysilicon layer(14) can maintain smooth straight line and overall profile is a square appearance because the sidewall is formed in perpendicular, while, in profiles in FIGs. 1(a) and 1(b), boundary plane between photoresist layer(16) and polysilicon layer(14) cannot maintain smooth straight line and overall profile is a reverse-trapezoid appearance because the sidewall is tilted.

Also in FIGs. 3(a) and 3(b), it can be known that trench phenomenon, which is appeared in the process for high density plasma etching, is not almost appeared.

Hence, one embodiment according to the present invention is ease to form a highly-integrated and ultra-fine pattern because the plane is smooth and perpendicularity is provided as shown in FIGs. 3(a) and 3(b).

And as the second embodiment according to the present invention, the method wherein F_2, SF_6, CF_4 or CHF_3 comprising fluorine is used as a main etching gas and one selected form a group consisting of CH_3Br, CH_2Br_2, $CHBr_3$, C_2H_5Br or $C_2H_4Br_2$, generating carbene structure intermediate by plasma discharge, is supplied as an additional gas so as to etch polysilicon layer which is a layer of a silicon-bearing material, may be used.

In the second embodiment mentioned above, other gases mixed for etching are same as in one embodiment and etching environment of the apparatus is almost same, and polymers in the sidewall, made by etching, act as a passivation and as a result, the appearance of the profiles is improved. Therefore, the second embodiment is suitable for formation of highly-integrated and ultra-fine pattern as in one embodiment.

And as third embodiment, the present invention can be applied in etching of silicon oxide layer and in third embodiment, using a gas wherein F_2, SF_6, CF_4 or CHF_3 comprising fluorine, which is a main etching gas for etching of typical silicon oxide layer, one selected form a group consisting of CH_3Br, CH_2Br_2, $CHBr_3$, C_2H_5Br or $C_2H_4Br_2$, generating carbene structure intermediate by plasma discharge, and other gases are mixed so as to etch silicon oxide layer, the same effects are resulted as in one embodiment.

And also as fourth embodiment, one of BrI or Br_2, wherein bromine is bonded to one atom belonging to halogen group, is supplied to a main etching gas by mixing to form polymers onto the sidewall so as to etch a layer of a silicon-bearing material. As fifth embodiment, BBr_3 is mixed as an additional gas together with a main etching gas to perform the etching and as a result, good profiles are obtained.

Besides dry etching of a layer of a silicon-bearing material as in first to fifth embodiments mentioned above, as sixth embodiment according to the present invention, component generating carbene structure intermediate by plasma discharge is used as an additional gas with regard to metal layer to form polymers in etched portion and the results of improvement of profiles and guarantee for perpendicularity of the sidewall were obtained.

Hence, improvement of etching profiles which is most difficult detail among details considered in dry etching will be achieved by polymers formed as intermediates of respective gases provided according to the present invention, and profiles of dry-etched layer achieved according to the present invention provide a perfect perpendicularity.

Therefore, according to the present invention, profiles of the etched layer is achieved so that it is sufficiently used in fabrication for semiconductor device requiring ultra-fine and high-integration, whereby high capacity and high function of semiconductor device can be obtained.

While the present invention has been shown and described with reference to particular embodiments, it will be understood by those skilled in the art that various changes in form and detail may be effected therein without departing from the spirit and scope of the invention which is defined by the appended claims.

WHAT IS CLAIMED IS :

1. A method for plasma etching in a process for fabrication of a semiconductor device, in which a plurality of supplying gases are converted to plasma state to etch the polysilicon layer on a wafer by a selective reaction and ion collision depending on the pattern masked on the upper part, characterized in that the method comprises a step of supplying a mixed gas of an etching gas containing chlorine and an additional gas which generates an intermediate of carbene structure by plasma discharge, as the supplying gas; and a step of forming a polymer generated in plasma state, which is a combined material of the intermediate, on the side walls of profiles of which the polysilicon layer is etched.

2. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 1, wherein the etching gas is selected from a group consisting of Cl_2, BCl, HCl or $SiCl_4$, or a mixture thereof.

3. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 1, wherein He or Ar gas (which is an inert gas) is supplied as a carrier gas in order to fall off the surface etching by-product of the polysilicon layer by collision.

4. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 1, wherein the additional gas is selected from a group consisting of CH_3Br, CH_2Br_2, $CHBr_3$, C_2H_5Br or $C_2H_4Br_2$, or the mixtures thereof.

5. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 1, wherein the intermediate of carbene structure is $C_xH_yBr_z$ (x, y, and z independently represents 0 or natural number).

6. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 5, wherein the intermediate is hydrogen bromide carbene (:CHBr).

7. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 5, wherein the intermediate is dihydrogen carbene ($:CH_2$).

8. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 5, wherein the intermediate is dibromocarbene($:CBr_2$).

9. A method for plasma etching in a process for

fabrication of a semiconductor device according to claim 1, wherein the etching is performed at room temperature and bromomethane(CH_3Br) is supplied as the additional gas.

10. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 1, wherein oxygen(O_2) is further supplied for etching selectivity between the layers, if the lower layer of the polysilicon is made of silicon oxide (SiO_2).

11. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 1 or 10, wherein the ratio of chlorine to oxygen supplied is 2:1 - 6:1.

12. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 1, wherein the etching gas and additional gas are converted to form an intermediate by a plasma source of inductive coupled plasma type to selectively etch the polysilicon layer.

13. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 1, wherein the etching gas and additional gas are converted to form an intermediate by a plasma source of capacitively

coupled plasma type to selectively etch the polysilicon layer.

14. A method for plasma etching in a process for fabrication of a semiconductor device, in which a plurality of supplying gases are converted to plasma state to etch the polysilicon layer on a wafer by a selective reaction and ion collision depending on the pattern masked on the upper part, characterized in that the method comprises a step of supplying a mixed gas of an etching gas containing fluorine and an additional gas which generates an intermediate of carbene structure by plasma discharge, as the supplying gas; and a step of forming a polymer generated in plasma state, which is a combined material of the intermediate, on the side walls of profiles of which the polysilicon layer is etched.

15. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 14, wherein the etching gas is selected from a group consisting of F_2, SF_6, CF_4 or CHF_3, or a mixture thereof.

16. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 14, wherein He or Ar gas (which is an inert gas) is supplied as a carrier gas in order to fall off the surface

etching by-product of the polysilicon layer by collision.

17. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 14, wherein the additional gas is selected from a group consisting of CH_3Br, CH_2Br_2, $CHBr_3$, C_2H_5Br or $C_2H_4Br_2$, or the mixtures thereof.

18. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 14, wherein the intermediate of carbene structure is $C_xH_yBr_z$ (x, y, and z independently represents 0 or natural number).

19. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 18, wherein the intermediate is hydrogen bromide carbene (:CHBr).

20. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 18, wherein the intermediate is dihydrogen carbene ($:CH_2$).

21. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 18, wherein the intermediate is dibromocarbene($:CBr_2$).

22. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 14, wherein oxygen(O_2) is further supplied for etching selectivity between the layers, if the lower layer of the polysilicon is made of silicon oxide (SiO_2).

23. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 14, wherein the etching gas and additional gas are converted to form an intermediate by a plasma source of inductive coupled plasma type to selectively etch the polysilicon layer.

24. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 14, wherein the etching gas and additional gas are converted to form an intermediate by a plasma source of capacitively coupled plasma type to selectively etch the polysilicon layer.

25. A method for plasma etching in a process for fabrication of a semiconductor device, in which a plurality of supplying gases are converted to plasma state to etch the silicon oxide layer on a wafer by a selective reaction and ion collision depending on the pattern masked on the upper part, characterized in that the method comprises a

step of supplying a mixed gas of an etching gas containing fluorine and an additional gas which generates an intermediate of carbene structure by plasma discharge, as the supplying gas; and a step of forming a polymer generated in plasma state, which is a combined material of the intermediate, on the side walls of profiles of which the silicon oxide layer is etched.

26. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 25, wherein the etching gas is selected from a group consisting of F_2, SF_6, CF_4 or CHF_3, or a mixture thereof.

27. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 25, wherein He or Ar gas (which is an inert gas) is supplied as a carrier gas in order to fall off the surface etching by-product of the silicon oxide layer by collision.

28. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 25, wherein the additional gas is selected from a group consisting of CH_3Br, CH_2Br_2, $CHBr_3$, C_2H_5Br or $C_2H_4Br_2$, or the mixtures thereof.

29. A method for plasma etching in a process for

fabrication of a semiconductor device according to claim 25, wherein the intermediate of carbene structure is $C_xH_yBr_z$ (x, y, and z independently represents 0 or natural number).

30. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 29, wherein the intermediate is hydrogen bromide carbene (:CHBr).

31. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 29, wherein the intermediate is dihydrogen carbene (:CH_2).

32. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 29, wherein the intermediate is dibromocarbene(:CBr_2).

33. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 25, wherein the etching gas and additional gas are converted to form an intermediate by a plasma source of inductive coupled plasma type to selectively etch the silicon oxide layer.

34. A method for plasma etching in a process for fabrication of a semiconductor device according to claim

25, wherein the etching gas and additional gas are converted to form an intermediate by a plasma source of capacitively coupled plasma type to selectively etch the silicon oxide layer.

35. A method for plasma etching in a process for fabrication of semiconductor device for etching of a silicon-bearing material on a wafer, wherein BrI or Br_2 (in which bromine and other halogen atom are bonded) is supplied with an etching gas to form a polymer for protecting the sidewalls of profiles formed by selective etching of the silicon-bearing layer.

36. A method for plasma etching in a process for fabrication of a semiconductor device, in which a plurality of supplying gases are converted to plasma state to etch the silicon-bearing layer on a wafer by a selective reaction and ion collision depending on the pattern masked on the upper part, wherein the etching gas and boron tribromide (BBr_3) are supplied as the supplying gas, whereby the polymer is formed on the sidewalls of profiles of which the silicon-bearing layer is etched by bromine and boron bromide generated from the plasma discharge.

37. A method for plasma etching in a process for fabrication of a semiconductor device, in which a plurality

of supplying gases are converted to plasma state to etch the metal layer on a wafer by a selective reaction and ion collision depending on the pattern masked on the upper part, characterized in that the method comprises a step of supplying a mixed gas of an etching gas and an additional gas which generates an intermediate of carbene structure by plasma discharge, as the supplying gas; and a step of forming a polymer generated in plasma state, which is a combined material of the intermediate, on the side walls of profiles of which the metal layer is etched.

38. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 37, wherein the etching gas is selected from a group consisting of Cl_2, BCl, HCl or $SiCl_4$, or a mixture thereof.

39. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 37, wherein He or Ar gas (which is an inert gas) is supplied as a carrier gas in order to fall off the surface etching by-product of the metal layer by collision.

40. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 37, wherein the etching gas is selected from a group consisting of F_2, SF_6, CF_4 or CHF_3, or a mixture thereof.

41. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 37, wherein the additional gas is selected from a group consisting of CH_3Br, CH_2Br_2, $CHBr_3$, C_2H_5Br or $C_2H_4Br_2$, or the mixtures thereof.

42. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 37, wherein the intermediate of carbene structure is $C_xH_yBr_z$ (x, y, and z independently represents 0 or natural number).

43. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 42, wherein the intermediate is hydrogen bromide carbene (:CHBr).

44. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 42, wherein the intermediate is dihydrogen carbene (:CH_2).

45. A method for plasma etching in a process for fabrication of a semiconductor device according to claim 42, wherein the intermediate is dibromocarbene(:CBr_2).

46. A method for plasma etching in a process for

fabrication of a semiconductor device according to claim 42, wherein oxygen(O_2) is further supplied for etching selectivity between the layers, if the lower layer of the metal layer is made of silicon oxide (SiO_2).

The Patent Office

31

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H1K(KLEXX,KLEXT,KLEXA,KLEXM)

Int Cl (Ed.6): H01L

Other: ON LINE,W.P.I.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP0334525 A1	G.E.C.	1
X	US5169487	MICRON TECHNOLOGY(See ref. to a carbene CFx in col.2 line25.)	1,37
X	US4855017	TEXAS (See col.9 lines25-39)	35
X	US4784720	TEXAS(See col.9 lines13-27)	35

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.