

Etching Method

The present invention relates to dry etching method and apparatus for use in the manufacture of thin film devices such as semi-conductor and liquid crystal device.

In a dry etching apparatus using polycrystalline silicon or aluminum alloy, it has been the usual practice that elements containing oxygen such as quartz, alumilite, or Al_2O_3 , ceramics are used as a material for the wall of an etching chamber. This is because these materials of high purity are available at a relatively low cost and their electric characteristics are stable.

A conventional dry etching apparatus will be described below. Fig. 4 is a diagram showing one model of a conventional inductive coupling type dry etching apparatus. An etching chamber 21 has an electromagnetic induction window 22 made of quartz mounted on an upper part thereof, on which a coil 23 is disposed. A high-frequency power source 24 is connected to this coil 23 through an impedance matching circuit 25. At the lower part of the etching chamber 21, there is an electrode 30 on which a substrate 28 is placed, and to which a high-frequency power source 31 is connected through an impedance matching circuit 32. Reference numeral 29 represents a substrate holding member. A reactive gas is introduced from an inlet 27 into the etching chamber 21 through a mass flow controller 26, and the construction is such that by means of an evacuating system 33, the pressure within the etching chamber 21 can be maintained to an appropriate level.

In the above arrangement, high-frequency voltage is applied to the coil 23 thereby to generate plasma 34, and etching is accomplished by beaming ions and radicals to the surface of the substrate 28.

When removing polycrystalline silicone or aluminum alloy by etching in the above dry etching device, there was a

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problem that the resist on the substrate 28 was also etched, due to oxygen. Oxygen is mixed into plasma 34 when the quartz of the electromagnetic induction window 22 is also etched thereby releasing silicon and oxygen into the plasma 34. The
5 materials of the side walls of the etching chamber 21 and of the substrate holding member 29 are also subject to etching thereby causing oxygen to admix into the plasma 34.

There was also a problem that a protective coating film mainly composed of oxygen is deposited on side walls of a
10 pattern formed by etching polycrystalline silicon, whereby the pattern dimensions were increased.

In view of the foregoing, an object of the present invention is to provide dry etching method and apparatus in which the amount of oxygen released into plasma from elements
15 constituting the etching chamber is reduced thereby to suppress etching of resist, by which precise etching performance can be achieved.

To accomplish the above object, the present invention provides a dry etching method including the procedures of:
20 reducing pressure inside of an etching chamber by means of an evacuation system; introducing a reactive gas; activating a plasma generating source; producing plasma from the reactive gas by inducing an electromagnetic field through an electromagnetic induction window; whereby a film on a
25 substrate placed within the etching chamber is removed; wherein a part or all of elements that constitute the etching chamber and are in contact with plasma are constructed of a material of which composition rate of oxygen is 50% or less.

Also, the present invention provides a dry etching
30 apparatus comprising: an etching chamber within which a substrate is placed to be subjected to an etching operation to remove a film on the substrate; an evacuation system for reducing pressure inside of the etching chamber; a system for introducing a reactive gas into the etching chamber; a plasma

generating source; wherein a part or all of elements that constitute the etching chamber and are in contact with plasma are constructed of a material of which composition rate of oxygen is 50% or less.

5 With the above arrangement, the admixing amount of oxygen into plasma can be reduced by constituting a part or all of the elements in contact with plasma by materials which contain little oxygen. Etching of resist can be thereby suppressed, and the protective coating film formed on the side
10 walls of patterns can be made thinner, whereby highly precise etching becomes possible.

It is particularly effective to reduce the amount of oxygen mixed in plasma, by constituting at least the inner side of the electromagnetic induction window of the etching
15 chamber by a material of which composition ratio of oxygen is 50% or less.

It is preferable to use silicon nitride film, silicon, silicon carbonate, carbon, aluminum nitride, polyimide, and polyamide, to achieve the effects of reducing oxygen in plasma,
20 since all of these contain quite a small amount of oxygen. Electric insulating property is also thereby improved.

Furthermore, the film to be etched is preferably of silicon, polycrystalline silicon, polycide, aluminum, aluminum alloy, titanium, titanium alloy, or tungsten, to fully exploit
25 the effects of the present invention.

Preferred embodiments of the present invention will be hereinafter described with reference to the accompanying drawings, wherein:

Fig. 1 is a schematic layout diagram of a dry etching
30 apparatus according to a first embodiment of the present invention;

Fig. 2 is a schematic layout diagram of a dry etching apparatus according to a second embodiment of the present invention;

Fig. 3 is a schematic layout diagram of a dry etching apparatus according to a third embodiment of the present invention; and

Fig. 4 is a schematic layout diagram of a conventional dry etching apparatus.

(First Embodiment)

Fig. 1 shows a dry etching apparatus equipped with a plasma source of inductive coupling type. An etching chamber 1 has an electromagnetic induction window 2 made of quartz mounted on an upper part thereof, on which a coil 3 is disposed. A high-frequency power source 4 is connected to this coil 3 through an impedance matching circuit 5. At the lower part of the etching chamber 1, there is an electrode 10 on which a substrate 8 is placed, and to which a high-frequency power source 11 is connected through an impedance matching circuit 12. Reference numeral 9 represents a substrate holding member. A reactive gas is introduced from an inlet 7 into the etching chamber 1 through a mass flow controller 6, and the construction is such that by means of an evacuating system 13, the pressure within the etching chamber 1 can be maintained to an appropriate level.

In this embodiment, the electromagnetic induction window 2 is constructed of silicon nitride in order to suppress supply of oxygen into plasma. The material of the substrate holding member 9 in contact with plasma is also made of silicon nitride.

By constituting the electromagnetic induction window 2 and the substrate holding member 9 that is in contact with plasma by silicon nitride as described above, it is possible to prevent oxygen from mixing into plasma.

Table 1 below shows measurement results of the etching rate of polycrystalline silicon and selectivity ratio thereof to resist in this embodiment where the electromagnetic induction window is constituted by silicon nitride in

comparison with the prior art wherein the electromagnetic induction window is constructed of quartz.

[Table 1]

Induction plate	SiN (present invention)	Quartz (prior art)
Etching rate of Poly-Si (nm/min)	190	200
Selectivity ratio of poly-Si to resist	5.6	2.8

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As can be seen from Table 1, in the case of using the electromagnetic induction window made of silicon nitride, the selectivity ratio of poly-Si to resist was increased to twice as large as that of the prior art, while the etching rate of polycrystalline silicon remained more or less the same.

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(Second Embodiment)

In this embodiment shown in Fig. 2, an electromagnetic induction window itself is made of quartz similarly as the prior art, but its face facing to the inside of the etching chamber 1, i.e., the face in contact with plasma is covered with a cover 15 consisting of silicon nitride. Release of oxygen is suppressed by this arrangement, too.

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20 (Third Embodiment)

The present invention in this embodiment is applied to an ECR type dry etching apparatus wherein plasma is generated by inducing microwaves into the etching chamber 1.

In Fig. 3, microwaves generated by a magnetron 17 are introduced to the upper part of the etching chamber 1 through waveguides 18, and induced into the etching chamber 1 through the microwave induction window 16. Reference numeral 19 represents an electromagnet disposed on the upper periphery of the etching chamber 1. In this embodiment, the microwave induction window 16 is constructed of silicon nitride in order

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to suppress supply of oxygen into plasma. The material of the substrate holding member 9 in contact with plasma is also made of silicon nitride.

By constituting the microwave induction window 16 and the substrate holding member 9 that is in contact with plasma by silicon nitride as described above, it is possible to prevent oxygen from mixing into plasma.

Although it has been described in the examples of the above embodiments that the electromagnetic induction window 2 and the substrate holding member 9 in contact with plasma are constituted by silicone nitride, it is more preferable to cover the entire wall surface of the etching chamber 1 with silicon nitride. Furthermore, generation of oxygen can be completely stopped by using silicon nitride in as many elements as possible constituting the etching chamber 1.

Other than the case wherein polycrystalline silicone is etched, the same effects can be achieved in etching of silicone, polycide, aluminum, aluminum alloy, titanium, titanium alloy, and tungsten.

Furthermore, materials other than silicon nitride as described above such as silicon, silicon carbonate, carbon, aluminum nitride, polyimide, and polyamide, which contain no oxygen, may also be used to achieve the same effects of the present invention. However, silicon nitride is most preferable in terms of life and other material properties.

The present invention may also be applied to a plasma CVD apparatus wherein a thin film is formed on a substrate placed in a vacuum chamber. Specifically, by constituting the elements that constitute the vacuum chamber and are in contact with plasma by silicon nitride similarly to the embodiments described above, it is possible to prevent oxygen from mixing into plasma, whereby contamination of thin film caused by oxygen can be prevented.



CLAIMS

1. A dry etching method including the procedures of:
evacuating inside of an etching chamber (1) by means of
5 an evacuation system (13);
introducing a reactive gas;
activating a plasma generating source (11);
producing plasma from the reactive gas by inducing an
electromagnetic field through an electromagnetic induction
10 window (2); whereby a film on a substrate (8) placed within
the etching chamber (1) is removed; wherein
a part or all of elements that constitute the etching
chamber (1) and are in contact with plasma are constructed of
a material of which composition rate of oxygen is 50% or less.
- 15 2. The dry etching method according to claim 1,
wherein at least an inner side of the electromagnetic
induction window (2) of the etching chamber (1) is made of a
material of which composition rate of oxygen is 50% or less.
- 20 3. The dry etching method according to claim 1,
wherein the material of which composition rate of oxygen is
50% or less is any of silicon nitride, silicon, silicon
carbonate, carbon, aluminum nitride, polyimide, and polyamide.
- 25 4. The dry etching method according to claim 1,
wherein the film to be etched is any of silicon,
polycrystalline silicon, polycide, aluminum, aluminum alloy,
titanium, titanium alloy, and tungsten.
5. A dry etching apparatus comprising:
an etching chamber (1) within which a substrate (8) is
placed to be subjected to an etching operation to remove a
30 film on the substrate (8);
an evacuation system (13) for evacuating inside of the
etching chamber (1);
a system for introducing a reactive gas into the etching
chamber (1);





a plasma generating source (11); wherein
a part or all of elements that constitute the etching
chamber (1) and are in contact with plasma are constructed of
a material of which composition rate of oxygen is 50% or less.

5 6. The dry etching apparatus according to claim 5,
wherein at least an inner side of the electromagnetic
induction window (2) of the etching chamber (1) is made of a
material of which composition rate of oxygen is 50% or less.

7. The dry etching apparatus according to claim 5,
10 wherein the material of which composition rate of oxygen is
50% or less is any of silicon nitride, silicon, silicon
carbonate, carbon, aluminum nitride, polyimide, and polyamide.

8. The dry etching apparatus according to claim 5,
wherein the film to be etched is any of silicon,
15 polycrystalline silicon, polycide, aluminum, aluminum alloy,
titanium, titanium alloy, and tungsten.

9. A plasma processing method including the procedures
of:

evacuating inside of a vacuum chamber by means of an
20 evacuation system;
introducing a reactive gas;
activating a plasma generating source;
producing plasma from the reactive gas by inducting an
electromagnetic field through an electromagnetic induction
25 window; whereby a plasma processing operation is performed to
a substrate placed within the vacuum chamber; wherein

a part or all of elements that constitute the vacuum
chamber and are in contact with plasma are constructed of a
material of which composition rate of oxygen is 50% or less.

30 10. The plasma processing method according to claim 1
wherein the plasma processing operation includes a chemical
vapor deposition process.

11. A plasma processing apparatus comprising:
a vacuum chamber within which a substrate is placed to



be subjected to plasma processing;

an evacuation system for evacuating inside of the vacuum chamber;

5 a system for introducing a reactive gas into the vacuum chamber;

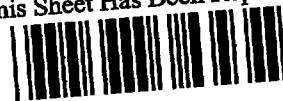
a plasma generating source; wherein

a part or all of elements that constitute the vacuum chamber and are in contact with plasma are constructed of a material of which composition rate of oxygen is 50% or less.

10 12. The plasma processing apparatus according to claim 11 wherein the plasma processing operation includes a chemical vapor deposition process.

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