APPARATUS FOR TREATING SUBSTRATES USING PLASMA, METHOD FOR SUPPLYING PLASMA AND METHOD FOR TREATING SUBSTRATES USING PLASMA

BACKGROUND

The present invention relates to apparatus and method for treating substrates. More specifically, the present invention is directed to apparatus and method for treating substrates using plasma.

A lithography process using a photoresist is necessary in semiconductor manufacturing. The photoresist is made of an organic high molecule that is sensitive to light or the mixture of a photosensitive agent and a high molecule. After the photoresist is exposed and developed, a photoresist pattern is formed on a substrate. The photoresist pattern is used to transcribe the pattern onto the substrate while etching the substrate or layers formed on the substrate. Such a high molecule is referred to as a photoresist, and a process of forming fine patterns on the substrate using a light source is referred to as a lithography process.

After being used for transcribing the pattern onto the substrate, the photeresist pattern is removed from the substrate by means of ashing.

In a conventional ashing process, oxygen plasma and photoresist react to each other while a wafer is placed on a heater chuck heated to a high temperature (200 to 300 degrees centigrade) in order to remove photoresist. An oxygen (O_2) gas is used as a reactive gas, and another gas may be mixed with the reactive gas to enhance ashing efficiency.

However, the conventional ashing process cannot avoid encountering problems that an oxide layer is formed on a substrate or a residue is remained. Since the oxide layer or the residue results in bad patterns, these problems must be overcome to improve characteristics of a semiconductor device.

SUMMARY OF THE INVENTION

Exemplary embodiments of the present invention are directed to an apparatus for treating substrates. In an exemplary embodiment, the apparatus may include: a first generation unit configured to supply a first source gas to a discharge space and discharge the supplied first source gas to generate a first plasma; a second generation unit configured to supply a second source gas onto a flow path of the first plasma and discharge the supplied second source gas by using the first plasma to generate a second plasma; and a process chamber to which the first plasma and the second plasma are supplied and in which a target substrate treated by using the first plasma and the second plasma is loaded.

Exemplary embodiments of the present invention are directed to a method for supplying plasma. In an exemplary embodiment, the method may include: supplying a first source gas to a discharge space and discharging the supplied first source gas by using a discharger to generate a first plasma; and supplying a second source gas onto a flow path of the first plasma and discharging the supplied second source gas by using the first plasma to generate a second plasma.

Exemplary embodiments of the present invention are directed to a method for treating substrates. In an exemplary embodiment, the method may include: loading a substrate into a process chamber; supplying a first plasma generated from a first source gas in the process chamber; supplying a second source gas onto a flow path of the first plasma; and supplying a second plasma generated by discharge using the first plasma to treat a substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a substrate treating apparatus according to the present invention.

FIG. 2 is a flowchart illustrating a substrate treating method according to the present invention.

FIGS. 3A through 3D are schematic views illustrating the flow of a substrate treating method according to the present invention.

FIG. 4A is a scanning electron microscope (SEM) photo showing a state after a substrate is treated using a conventional substrate treating apparatus, and FIG. 4B is a SEM photo showing a state after a substrate is treated using a substrate treating apparatus according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred

embodiments of the invention are shown. This invention, however, may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the thicknesses of layers and regions are exaggerated for clarity.

While a wafer will be described as an example of a substrate, the present invention is not limited thereto. Further, while embodiments of the present invention will be described with respect to an ashing process for stripping photoresist on a wafer, the present invention is not limited thereto and may be applied to a cleaning process, an etching process, a surface modification process, and all processes using plasma.

FIG. 1 illustrates a substrate treating apparatus 1 according to the present invention. The substrate treating apparatus 1 includes a process chamber 100 in which a wafer W is loaded and a plasma supply unit 200 installed on the process chamber 200 configured to supply plasma to the wafer W loaded in the process chamber 100.

The process chamber 100 has a top where an opening is formed, a bottom wall disposed in parallel with the ground, and a sidewall extending perpendicularly to the bottom wall. As illustrated in FIG. 1, the process chamber 100 is grounded to prevent ions in plasma generated over the process chamber 100 from entering the process chamber 100, which will be described in detail later.

A chuck 120 is provided inside the process chamber 100, and a wafer W is loaded on the chuck 120. The chuck 120 is disposed over the

bottom wall in parallel therewith. The chuck 120 serves to hold a loaded wafer W. A heater (not shown) may be provided inside the chuck 120 to heat the held wafer W to a preset process temperature.

As illustrated in FIG. 1, the chuck 120 is grounded to prevent ions in plasma generated over the process chamber 100 from entering the process chamber 100, which will be described in detail later.

A plurality of exhaust holes 102 are formed on the bottom wall of the chuck 120 along the circumference of the chuck 120. The plurality of exhaust holes 102 are provided to lower an inner pressure of the substrate treating apparatus 1 during a process or to exhaust reactive byproducts generated inside the substrate treating apparatus 1 to the outside of the process chamber 100. The exhaust hole 102 is connected to an exhaust line 140, and the reactive byproducts inside the process chamber 100 are exhausted to the outside of the process chamber 100. An exhaust valve 142 is installed on the exhaust line 140 to open and close the exhaust line 140.

A plasma supply unit 200 is installed on the process chamber 100. The plasma supply unit 200 generates plasma used to strip photoresist on a wafer W and supplies the generated plasma into the process chamber 100. The plasma supply unit 200 includes a plasma chamber 220, an inner tube 240, a discharger 260, a diffusion duct 280, and a baffle 290.

The inner tube 240 has a bottom where an opening is formed, a top wall, and a sidewall extending downwardly toward the process chamber 100 from the top wall. The inner tube 240 may be made of quartz, and a discharge space 242 is defined by the top surface and the sidewall of the inner tube 240. The discharge space 242 is a space where externally

supplied source gases are discharged to generate plasma. A first source gas is supplied to the discharge space 242 along a first supply line 222a which will be described later. The first source gas is discharged by the discharger 260 connected to the sidewall of the inner tube 240. In the discharge space 242, plasma is generated from the first source gas. The generated plasma migrates to the process chamber 100 through an opening formed therebelow.

A first inflow hole 244 is formed at the top wall of the inner tube 240, and the first source gas flows in the discharge space 242 through the first inflow hole 244.

The plasma chamber 220 surrounds the outer side of the inner tube 240. As described later, the plasma chamber 220 may isolate a space, where first plasma and second plasma are generated, from the exterior to make the isolated space vacuum. The plasma chamber 220 includes a top wall corresponding to the top wall of the inner tube 240 and a sidewall corresponding to the sidewall of the inner tube 240. A first through-hole 222 is formed at the top wall of the plasma chamber 220 to correspond to the first inflow hole 244. A first supply line 222a is connected to the first through-hole 222, and the first source gas flows along the first supply line 222a. A first valve 22b is installed on the first supply line 222a to open and close the first supply line 222a.

A second inflow hole 224 is formed at a lower sidewall of the plasma chamber 220. The second source gas flows into the plasma chamber 220 through the second inflow hole 224. A second supply line 224a is connected to the second inflow hole 224, and the second source gas flows

along the second supply line 224a. A second valve 224b is installed on the second supply line 224a to open and close the second supply line 224a.

The second inflow hole 224 is disposed at the lower portion end of the inner tube 240. Accordingly, the second source gas is supplied into the plasma chamber 220 through the second inflow hole 224 and onto a path along which the first plasma migrates. This is done for generating the second plasma from the second source gas by using the energy of the first plasma.

A second through-hole 226 is formed at the other side of the plasma chamber 220. A discharger 260 is connected to the second through-hole 226 and configured to discharge the first source gas supplied into the discharge space 242. The discharger 260 includes a microwave oscillator 262 for oscillating a microwave and a waveguide 264 for transmitting a microwave. One side of the waveguide 264 is connected to the microwave oscillator 262, and the other side thereof is connected to the inner tube 240 through the second through-hole 226. The second through-hole 226 is installed adjacent to the first inflow hole 244, allowing a microwave transmitted through the waveguide 264 to discharge the first source gas supplied on the discharge space 242 through the first inflow hole 244 and generating the first plasma on the discharge space 242.

While this embodiment is characterized in that the first source gas on a discharge space 242 is discharged by using the microwave oscillator 262 and the waveguide 264, it is apparent to those skilled in the art that the discharger 260 may be replaced variously.

As illustrated in FIG. 1, a diffusion duct 280 is connected to the bottom of the plasma chamber 220 and the bottom of the diffusion duct 280 is connected to the top end of the process chamber 100. Since the diffusion duct 280 has a cross section tapering upwardly, the first plasma and the second plasma exhausted to the outside of the plasma chamber 220 through the opening formed at the bottom of the plasma chamber 220 are diffused along the diffusion duct 280. A baffle 290 is installed between the diffusion duct 280 and the process chamber 100. Since a plurality of through-holes 292 are formed on the battle 290, the first plasma and the second plasma migrating to the lower portion in the process chamber 100 through the diffusion duct 280 are uniformly supplied onto a wafer W.

Among elements contained in plasma, free radicals and ions are mainly associated with a process using the plasma. The free radicals have incomplete binding and are electrically neutral. Due to the incomplete binding, reactivity of the free radicals is significantly high. Typically, the free radicals chemically react to materials on the wafer W to perform the process. However, the ions take on a negative charge to be accelerated depending on a potential difference in a predetermined direction and chemically react to the material on the wafer W to perform the process.

Free radicals and ions are also contained in the first plasma and the second plasma migrating over the baffle 290 through the diffusion duct 280. The free radicals migrate over the wafer W to chemically react to photoresist on the wafer W, while the ions taking on a predetermined charge are accelerated toward the wafer W and collide against the photoresist on the wafer W to cause a physical reaction. In the case where the accelerated ions

collide against patterns except the photoresist, a shock may be produced to attack fine patterns. The patterns on the wafer W take on a preset charge for the next process. However, in the case where the ions collide against the patterns on the wafer W, the preset charge amount of the patterns may be varied to have an effect on the next process.

To overcome the above disadvantage, the baffle 290 is grounded as illustrated in FIG. 1. The free radicals in the first plasma and the second plasma migrating over the baffle 290 migrate over the wafer W via the through-hole 292 formed on the baffle 290, while the ions therein are isolated by the grounded baffle 290 to be prevented from reaching the wafer W. That is, the wafer W is not attacked by the ions because the only free radicals arrive on the wafer W.

A substrate treating method will now be described with reference to FIGS. 2 through 3D.

A wafer W is loaded into a process chamber 100 (S10). The loaded wafer W is placed on a chuck 120. As discussed above, a heater (not shown) may be provided inside the chuck 120 and configured to heat the wafer W to a process temperature.

A first valve 22b on a first supply line 222a is opened, and a first source gas is supplied in a discharge space 242 inside an inner tube through the first supply line 22a (S20). The first source gas is supplied into the discharge space 242 through a first inflow hole 244 of the inner tube 240.

As illustrated in FIG. 3A, the first source gas in the discharge space 242 is discharged by using a discharger 260 (S30). A microwave oscillated from a microwave oscillator 262 is transmitted to the outer wall of

the inner tube 240 through a waveguide 264. The first source gas in the discharge space 242 is discharged by the transmitted microwave to generate first plasma from the first source gas.

Before supplying the first source gas in the discharge space 242, the discharge space 242 must be maintained at a vacuum state. For this reason, an inner pressure of the discharge space 242 is lowered through an exhaust hole 102 and an exhaust line 140 provided at a bottom wall of the process chamber 100 while the discharge space 242 is maintained at the vacuum state.

As illustrated in FIG. 3B, the generated first plasma migrates downwardly through a diffusion duct 280 in a flow direction of the first source gas supplied through a first inflow hole 244. At this point, because a baffle 290 provided at the bottom end of the diffusion duct 280 is in a grounded state, free radicals ○ in the first plasma migrate over the wafer W through a plurality of through-holes 292 and ions ⊕ in the first plasma are isolated by the baffle 290, as previously stated. The free radicals migrating over the wafer W react to photoresist on the wafer W to primarily strip the photoresist (S40).

As described above, the first source gas is provided for primarily stripping the wafer W under the plasma state. The first source gas may be an oxygen (O_2) gas or a mixed gas. The mixed gas may beoxygen (O_2) and nitrogen (N_2), or oxygen (O_2) and H_2N_2 to enhance efficiency of an ashing process. Moreover, various kinds of gases may be used as the first source gas. Especially many kinds of gases may be used to strip the

photoresist on the wafer W, which will be understood by those skilled in the art.

As illustrated in FIG. 3C, a second source gas is supplied on a flow path of the first plasma drained downwardly through the opening formed at the bottom of the inner tube 240 after being generated in the discharge space 242 (S50). When a second supply line 224a is opened using a second valve 224b, the second source gas is supplied on the flow path of the first plasma through the second supply line 224a.

The first plasma generated by absorbing energy from a microwave has a high energy level, and the second source gas supplied on the flow path of the first plasma absorbs energy by means of the energy transfer with the first plasma. Thus, second plasma is generated from the second source gas (S60).

As illustrated in FIG. 3D, the generated second plasma migrates downwardly through the diffusion duct 280 in a flow direction of the first source gas supplied through the first inflow hole 244. At this point, because the baffle 290 provided at the bottom end of the diffusion duct 280 is in a grounded state, the free radicals □ in the second plasma migrate over the wafer W through a plurality of through-holes 292 and the ions ■ in the second plasma are isolated by the baffle 290, as stated previously. The free radicals migrating over the wafer W react to the photoresist on the wafer W to secondarily strip the photoresist and reactive byproducts (S70).

As described above, the second source gas is used to strip the photoresist or residues on the wafer W after the photoresist on the wafer W is stripped by using oxygen plasma. As mentioned above, the second plasma

is generated from the second source gas by discharge and the residues or the like on the wafer W are removed by using the second plasma. The second source gas may be a fluorine-based gas (e.g., CF_4 or CHF_3) and has a higher reactivity (e.g., ashing rate) than the first source gas. While this embodiment is characterized in the use of a fluorine-based gas, it is apparent to those skilled in the art that a variety of other gases may be used.

However, even a small amount of added second source gas may cause a pattern on the wafer W to be deformed or attacked and may cause a chamber in which plasma is generated to be damaged during the generation of the plasma. Thus, the second source gas is indirectly discharged.

There are two reasons for indirect discharge of the second source gas, as set forth below.

Firstly, when a second source gas having a higher reactivity than a first source gas is directly discharged by the discharger 260, second plasma generated by direct discharge has significantly high energy. If the significantly high energy is supplied onto the wafer W, a pattern on the wafer W may be deformed or attacked. However, when the second source gas is indirectly discharged, second plasma generated by indirect discharge has a lower energy than by the direct discharge. Thus, the affect on the pattern may be reduced.

Secondly, when a second source gas having a higher reactivity than a first source gas is directly discharged inside the inner tube 240 made of quartz, the inner tube 240 may be damaged.

To solve the above problems, the second source gas is indirectly discharged at the outside of the inner tube 240 to generate the second plasma.

FIG. 4A is a scanning electron microscope (SEM) photo showing a state after a wafer W is treated using a conventional substrate treating apparatus, and FIG. 4B is a SEM photo showing a state after a wafer W is treated using a substrate treating apparatus according to the present invention.

As described above, second plasma generated by direct discharge has significantly high energy. Hence, when the second plasma is supplied onto a wafer W, the pattern on a wafer W is deformed or attacked, as illustrated in FIG. 4A. However, second plasma generated by indirect discharge has relatively low energy to prevent the pattern on a wafer W from being deformed or attacked.

According to the present invention, photoresist or residues on a substrate are effectively stripped. Moreover, deformation of patterns on the substrate or damage of an inner tube is suppressed.

Although the present invention has been described in connection with the embodiment of the present invention illustrated in the accompanying drawings, it is not limited thereto. It will be apparent to those skilled in the art that various substitutions, modifications and changes may be made without departing from the scope and spirit of the invention.

WHAT IS CLAIMED IS:

1. An apparatus for treating substrates, comprising:

a first generation unit configured to supply a first source gas to a discharge space and discharge the supplied first source gas to generate a first plasma;

a second generation unit configured to supply a second source gas onto a flow path of the first plasma and discharge the supplied second source gas by using the first plasma to generate a second plasma; and

a process chamber to which the first plasma and the second plasma are supplied and in which a target substrate treated by using the first plasma and the second plasma is loaded.

2. The apparatus of claim 1, wherein the first generation unit comprises:

an inner tube disposed at one side of the process chamber and configured to define the discharge space where the first plasma is generated;

a discharger connected to the inner tube and configured to discharge the first source gas in the discharge space; and

a first supply line connected to the inner tube and configured to supply the first source gas to the discharge space.

3. The apparatus of claim 2, wherein the second generation unit is provided between the inner tube and the process chamber, and includes a

second supply line configured to supply the second source gas onto the flow path of the first plasma.

4. The apparatus of claim 3, wherein the second supply line includes a gas supply line configured to supply a second source gas having a higher reactivity than the first source gas.

5. The apparatus of claim 4, wherein the gas supply line is configured to supply a fluorine-based gas.

6. The apparatus of claim 5, wherein the fluorine-based gas includes at least one of CF_4 and CHF_3.

7. The apparatus of claim 2, further comprising:

a diffusion duct provided between the plasma chamber and the process chamber, the diffusion duct having a cross section tapering upwardly.

8. The apparatus of claim 2, further comprising:

a baffle, provided between the plasma chamber and the process chamber, where a plurality of through-holes are formed.

9. The apparatus of claim 8, wherein the baffle is grounded.

10. The apparatus of claim 2, wherein the first supply line includes an oxygen supply line configured to supply an oxygen gas.

11. The apparatus of claim 1, wherein the process chamber is disposed below the first and second generation units; and

wherein the first plasma and the second plasma are supplied into the process chamber by means of a downstream method.

12. The apparatus of claim 1, being used in an ashing process.

13. A method for supplying plasma, the method comprising:

supplying a first source gas to a discharge space and discharging the supplied first source gas by using a discharger to generate a first plasma; and

supplying a second source gas onto a flow path of the first plasma and discharging the supplied second source gas by using the first plasma to generate a second plasma.

14. The method of claim 13, wherein the second source gas is supplied onto the flow path of the first plasma drained from the discharge space.

15. The method of claim 13, wherein the second source gas has a higher reactivity than the first source gas.

16. The method of claim 13, wherein the first plasma and the second plasma are supplied via a plurality of through-holes formed at a baffle.

17. The method of claim 16, wherein the baffle is grounded and ions in the first plasma and the second plasma are filtered by using the baffle.

18. A method for treating substrates, the method comprising:

loading a substrate into a process chamber;

supplying a first plasma generated from a first source gas in the process chamber;

supplying a second source gas onto a flow path of the first plasma; and

supplying a second plasma generated by discharge using the first plasma to treat a substrate.

19. The method of claim 18, wherein the first source gas supplied to a discharge space is discharged by using a discharger to generate the first plasma.

20. The method of claim 19, wherein the second source gas is supplied onto the flow path of the first plasma drained to the process chamber from the discharge space.

21. The method of claim 18, wherein the first plasma and the second plasma are supplied via a plurality of through-holes formed at a baffle.

22. The method of claim 21, wherein the baffle is grounded and ions in the first plasma and the second plasma are filtered by using the baffle.

23. The method of claim 18, wherein the second source gas has a higher reactivity than the first source gas.

24. The method of claim 23, wherein the second source gas includes a fluorine-based gas.

25. The method of claim 24, wherein the fluorine-based gas includes at least one of CF_4 and CHF_3.

26. The method of claim 18, wherein the first plasma and the second plasma are supplied into the process chamber by means of a downstream method.

27. The method of claim 18, being used in an ashing process.