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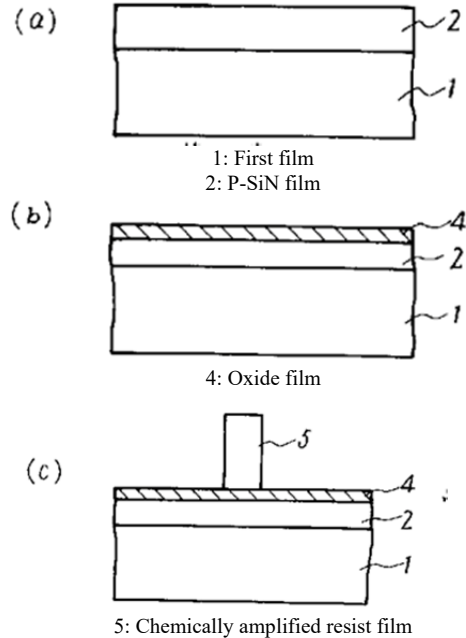
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(54) [Title of Invention] Method for manufacturing a semiconductor device

(57) [Summary]

[Objective] To obtain a semiconductor device capable of improving the patterning precision of a chemically amplified resist.

[Structure] Plasma nitride film 2 is laminated on a first film 1, plasma treatment using a gas having oxidizing power is applied to the upper surface of plasma nitride film 2 to form oxide film 4, and a chemically amplified resist film 5 is coated on oxide film 4 and patterned.



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[Scope of Patent Claims]

[Claim 1] A method for manufacturing a semiconductor device, characterized by comprising: a step of laminating a plasma nitride film or a plasma oxynitride film on a first film, a step of forming an oxide film by subjecting the upper surface of said plasma nitride film or a plasma oxynitride film to a plasma treatment using a gas having oxidizing power, and a step of coating a chemically amplified resist on said oxide film and patterning the same.

[Claim 2] The method for manufacturing a semiconductor device according to Claim 1, wherein plasma treatment is carried out in a parallel plate type chemical vapor deposition apparatus and the processing conditions are set such that the distance between the electrodes is 5 mm–15 mm, the pressure inside the chamber is 1.6 Torr–6 Torr, the plasma output is 0.3 w/cm^2 – 3 w/cm^2 , the flow rate of said gas having oxidizing power is 1 l/min–5 l/min, and the treatment time is 5 sec–180 sec.

[Claim 3] A method for manufacturing a semiconductor device, characterized by comprising: a step of laminating a plasma oxynitride film on a first film, a step of performing sputter etching of argon or nitrogen on the upper surface of said plasma oxynitride film, and a step of coating a chemically amplified resist on said plasma oxynitride film and patterning the same.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Application] The present invention relates to a method of manufacturing a semiconductor device for accurately patterning a chemically amplified resist.

[0002]

[Prior Art] Figure 5 is a cross-sectional view showing a manufacturing process of a conventional semiconductor device. In the figure, 1 is a first film made of a material having high reflectance such as aluminum, tungsten or the like formed on a semiconductor substrate (not shown,) 2 is a plasma nitride film formed on first film 1 for example, as an antireflection film formed with a thickness of 100–1000 angstroms (hereinafter referred to as a P-SiN film,) and 3 is a positive chemically amplified resist film formed on P-SiN film 2.

[0003] Next, the manufacturing process of the conventional semiconductor device configured as described above will be described. First, P-SiN film 2 is laminated on first film 1 on the semiconductor substrate. At this time, impurities such as nitrogen atoms and nitrogen molecules adhere to the upper surface of the P-SiN film 2 (Figure 5 (a.)) Next, a chemically amplified resist is applied on P-SiN film 2 and patterned to form a positive chemically amplified resist film 3 (Figure 5 (b.)) At this time, nitrogen atoms and nitrogen molecules adhering to P-SiN film 2 react with hydrogen atoms in chemically amplified resist film 3, for example when a pattern of $0.35 \mu\text{m}$ is formed, tugging of 0.05 – $0.10 \mu\text{m}$ occurs on the side of chemically amplified resist film 3, which is in contact with P-SiN film 2 as shown in Figure 5 (b.)

[0004] In addition, although positive chemically amplified resist film 3 was described in the above-described conventional

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example, the same reaction occurs even with a negative chemically amplified resist film. In this case, collapse occurs on the side of the chemically amplified resist film that is in contact with the P-SiN film. In addition, although the example of the P-SiN film was shown as the antireflection film in the above conventional example, the same phenomenon also occurs in plasma oxynitride film (hereinafter referred to as P-SiON film.)

[0005]

[Problem to be Solved by the Invention] The conventional semiconductor device is configured as described above, and is provided with P-SiN film 2 or a P-SiON film as an antireflection film for improving the accuracy of patterning a chemically amplified resist on first film 1. However, since nitrogen atoms and nitrogen molecules adhere to the upper surface of P-SiN film 2 or the P-SiON film and nitrogen atoms in P-SiN film 2 react with hydrogen atoms in the chemically amplified resist film, there is a problem that the accuracy of patterning of the chemically amplified resist is lowered.

[0006] The objective of the present invention is to provide a method for manufacturing a semiconductor device capable of improving the patterning precision of a chemically amplified resist.

[0007]

[Method for Solving the Problem] The method for manufacturing a semiconductor device in Claim 1 of the present invention is a method in which plasma nitride film or plasma oxynitride film is laminated on a first film, plasma treatment using a gas having oxidizing power is applied to the upper surface of the plasma nitride film or plasma oxynitride film to form an oxide film, and a chemically amplified resist is coated on the oxide film and patterning is carried out.

[0008] In addition, the method for manufacturing a semiconductor device in Claim 2 of the present invention is a method in which, in Claim 1, plasma treatment is carried out in a parallel plate type chemical vapor deposition apparatus and the processing conditions are set such that the distance between the electrodes is 5 mm–15 mm, the pressure inside the chamber is 1.6 Torr–6 Torr, the plasma output is 0.3 w/cm^2 – 3 w/cm^2 , the flow rate of said gas having oxidizing power is 1 l/min–5 l/min, and the treatment time is 5 sec–180 sec.

[0009] In addition, the method for manufacturing a semiconductor device in Claim 3 of the present invention is a method in which a plasma oxynitride film is laminated on a first film, a sputter etching of argon or nitrogen is performed on the upper surface of the plasma oxynitride film, and a chemically amplified resist is coated on the oxide film and patterning is carried out.

[0010]

[Effect] Since the method for manufacturing a semiconductor device according to Claim 1 of the present invention is such that a plasma nitride film or plasma oxynitride film is laminated on a first film, plasma treatment using a gas having oxidizing power is applied to the upper surface of the plasma nitride film or plasma oxynitride film to form an oxide film and a chemically amplified resist is coated on the oxide film and patterned, nitrogen is removed from the plasma nitride film or the plasma oxynitride film so as to prevent reaction between the nitrogen

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and the chemically amplified resist.

[0011] In addition, since the method for manufacturing a semiconductor device according to Claim 2 of the present invention is such that plasma treatment is carried out in a parallel plate type chemical vapor deposition apparatus and the processing conditions are set such that the distance between the electrodes is 5 mm–15 mm, the pressure inside the chamber is 1.6 Torr–6 Torr, the plasma output is 0.3 w/cm²–3 w/cm², the flow rate of said gas having oxidizing power is 1 l/min–5 l/min, and the treatment time is 5 sec–180 sec, an oxide film having the desired thickness is formed.

[0012] In addition, since the method for manufacturing a semiconductor device according to Claim 3 of the present invention is such that a plasma oxynitride film is laminated on a first film, a sputter etching of argon or nitrogen is performed on the upper surface of the plasma oxynitride film, and a chemically amplified resist is applied on the plasma oxynitride film for patterning, the nitrogen on the plasma oxynitride film is removed to prevent reaction between this nitrogen and the chemically amplified resist.

[0013]

[Embodiments]

Embodiment 1. Below, embodiments of the present invention will be described with reference to the drawings. Figure 1 is a cross-sectional view showing the manufacturing process of a semiconductor device in Embodiment 1 of the present invention. In the figure, parts similar to those in the conventional case are denoted by the same reference numerals, and description thereof is omitted. 4 is an oxide film formed on the upper surface of the P-SiN film 2 at a thickness of, for example, 40–100 angstroms, and 5 is a positive chemically amplified resist film formed on oxide film 4.

[0014] Next, the manufacturing process of the semiconductor device of Embodiment 1 configured as described above will be described. First, P-SiN film 2 is laminated on first film 1 on the semiconductor substrate. At this time, impurities such as nitrogen atoms and nitrogen molecules adhere to the upper surface of P-SiN film 2 (Figure 1 (a.)) At this time, P-SiN film 2 is formed by a parallel plate type plasma chemical vapor deposition apparatus as shown in Figure 2, using a gas system such as silane, nitrous oxide and nitrogen.

[0015] Next, the upper surface of P-SiN film 2 is formed by using the same apparatus subsequently to the formation of P-SiN film 2, and oxide film 4 is formed by plasma treatment with a gas having oxidizing power such as nitrous oxide (Figure 1 (b.)) At this time, nitrogen atoms and nitrogen molecules on the upper surface of P-SiN film 2 and nitrogen atoms in P-SiN film 2 are removed by oxygen atoms in the nitrous oxide, oxygen atoms are introduced instead and oxide film 4 is formed. Next, a chemically amplified resist is coated on oxide film 4 and patterned to form positive chemically amplified resist film 5 (Figure 1 (c.))

[0016] Plasma processing using the parallel plate type plasma chemical vapor deposition apparatus of Figure 2 during the above manufacturing process will be described in detail below. Figure 2 is a cross-sectional view of a parallel plate type plasma chemical vapor deposition apparatus. In the figure, 6 is a chamber, 7 and 8 are flat plate type upper and lower electrodes provided in parallel in the chamber 6, 9 is the distance between these electrodes, 10 is

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a plasma power supply connected to upper electrode 7.

[0017] The following experiment was attempted using the apparatus of Figure 2. Plasma treatment using nitrous oxide as a gas having oxidizing power after forming a P-SiN film to a thickness of 450 angstroms on a silicon substrate was performed under varying the processing conditions of the apparatus of Figure 2, the formation of an oxide film having a thickness of a few angstroms was examined by XPS (abbreviation of X-ray Photoelectron Spectroscopy,) and the results are shown in Figure 3. According to Figure 3, it was found that suitable processing conditions are as follows: the distance between the electrodes is 5–15 mm, the pressure in the chamber is 1.6–6 Torr, the flow rate of nitrous oxide is 1–5 l/min, the plasma output is, for example, for a wafer 8 inches in diameter, 0.3–3 w/cm², and the processing time is 5–180 sec. In addition, it can be inferred that the same result can be obtained regardless of whether P-SiON film is used instead of P-SiN film or a gas having oxidizing power is used instead of nitrous oxide.

[0018] In other words, if the above process conditions are satisfied, oxide film 4 can be formed to a thickness of 40 angstroms or more on the upper surface of P-SiN film 2, the nitrogen atoms at the upper part (depth of 40 angstroms) of P-SiN film 2 are removed, and it is possible to reliably prevent the reaction with the chemically amplified resist film 5. In addition, since the thickness of oxide film 4 can be suppressed to 100 angstroms or less, there is no influence on the reflectance of the lower P-SiN film 4 as an anti-reflection film.

[0019] Since, in the manufacturing method of the semiconductor device of Embodiment 1 manufactured as described above, nitrogen atoms and nitrogen molecules adhering to the upper surface of P-SiN film 2 and nitrogen atoms in P-SiN film 2 are removed and oxide film 4 are formed, it is possible to prevent reaction with chemically amplified resist film 5 without impairing the function of P-SiN film 2 as an antireflection film is not impaired, and accordingly it is possible to perform accurate patterning. In addition, since oxide film 4 can be formed continuously in the same apparatus as the film formation of P-SiN film 2, the increase in the number of steps can be minimized.

[0020] Embodiment 2. Although the example of P-SiN film 2 was described in Embodiment 1 above, it goes without saying that the same effects as in the above-described Embodiment 1 can also be obtained also in the case of using a P-SiON film.

[0021] Embodiment 3. Although nitrous oxide was used as a gas having oxidizing power for plasma processing in each of the above-described embodiments, it goes without saying that any gas may be used as long as it has oxidizing power, and it goes without saying that the same effect is exhibited even if, for example, oxygen, is used.

[0022] Embodiment 4. Figure 4 is a diagram for explaining the principle of the manufacturing process of the semiconductor device in Embodiment 4 of the present invention. In the figure, 6 is a P-SiON film formed as an antireflection film on first film 1 at a thickness of, for example, 100–1000 angstroms, 11 is an argon atom, 12 is a nitrogen atom, and 13 is a nitrogen molecule.

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[0023] Next, the manufacturing process of the semiconductor device of Embodiment 4 will be described with reference to Figure 2 and Figure 4. First, P-SiON film 6 is laminated on first film 1 with a gas system such as silane, nitrous oxide and nitrogen using the apparatus of Figure 2. At this time, impurities such as nitrogen atoms and nitrogen molecules adhere to the upper surface of P-SiON film 6. Next, argon sputter etching is carried out intact in the apparatus of Figure 2. Then, as shown in Figure 4, nitrogen atoms 12 and nitrogen molecules 13 on P-SiON film 6 are discharged to argon atoms 11, and nitrogen atoms 12 and nitrogen molecules 13 on P-SiON film 6 are removed. Next, patterning of the chemically amplified resist is carried out in the same manner as in the above-described Embodiment 1, and patterning is carried out in the same manner as the above-described Embodiment 1.

[0024] In the method of manufacturing the semiconductor device of Embodiment 4 manufactured as described above has the same effect as that of the above-described Embodiment 1. It should be noted that only nitrogen atoms 12 and nitrogen molecules 13 attached to the upper surface of P-SiON film 6 are removed here, unlike in Embodiment 1. However, since oxygen is sufficiently present in P-SiON film 6, reaction with the chemically amplified resist does not occur even if the nitrogen in P-SiON film 6 is not removed.

[0025] Embodiment 5. Although the example using argon sputter etching is shown in the above-described Embodiment 4, the present invention is not limited to this, and it goes without saying that the same effects as those of the above-described Embodiment 4 can be obtained even if, for example, nitrogen sputter etching is used.

[0026] It should be noted that, although the P-SiN film and the P-SiON film as the antireflection film are not particularly limited in each of the above embodiments, it is a matter of course that they are formed with the processing conditions, deposition time, etc. adjusted such that a predetermined reflectance is obtained with respect to the wavelength used for exposure in patterning the chemically amplified resist.

[0027]

[Effects of the Invention] As described above, according to Claim 1 of the present invention, since a plasma nitride film or a plasma oxynitride film is laminated on a first film and a plasma treatment using a gas having oxidizing power is applied to the upper surface of the plasma nitride film or the plasma oxynitride

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film ** to form an oxide film and a chemically amplified resist is applied and patterned on an oxide film, it is possible to provide a method for manufacturing a semiconductor device capable of improving the patterning precision of a chemically amplified resist.

[0028] In addition, according to Claim 2 of the present invention, since, plasma treatment is carried out in a parallel plate type chemical vapor deposition apparatus and the processing conditions are set such that the distance between the electrodes is 5 mm–15 mm, the pressure inside the chamber is 1.6 Torr–6 Torr, the plasma output is 0.3 w/cm²–3 w/cm², the flow rate of said gas having oxidizing power is 1 l/min–5 l/min, and the treatment time is 5 sec–180 sec in Claim 1, it is possible to provide a method for manufacturing a semiconductor device capable of further improving the patterning precision of a chemically amplified resist.

[0029] In addition, according to Claim 3 of the present invention since a plasma oxynitride film is laminated on a first film, a sputter etching of argon or nitrogen is performed on the upper surface of the plasma oxynitride film, a chemically amplified resist is applied on the plasma oxynitride film, and patterning is performed, it is possible to provide a method for manufacturing a semiconductor device capable of improving the patterning precision of a chemically amplified resist.

[Brief Description of the Drawings]

[Figure 1] A cross-sectional view showing the manufacturing process for a semiconductor device in Embodiment 1 of the present invention.

[Figure 2] A cross-sectional view showing a configuration of a general parallel plate type chemical vapor deposition apparatus.

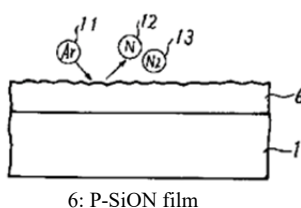
[Figure 3] A diagram showing experimental data for manufacturing process of a semiconductor device in Embodiment 1.

[Figure 4] A diagram for explaining the principle of the manufacturing process of the semiconductor device in Embodiment 4 of the present invention.

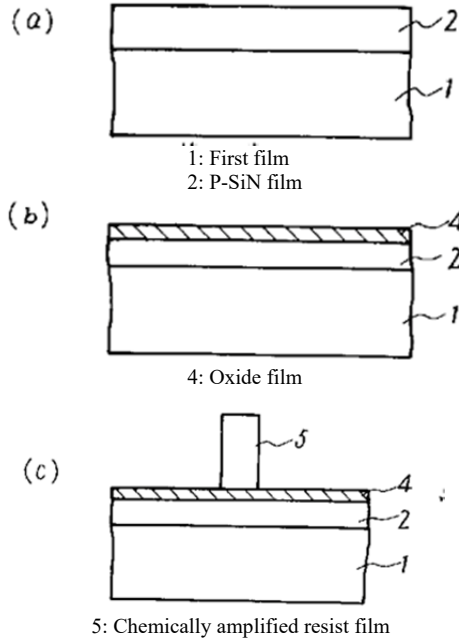
[Figure 5] A cross-sectional view showing a manufacturing process of a conventional semiconductor device.

[Explanation of Reference Numbers] 1 First film, 2 P-SiN film, 4 Oxide film, 5 Chemically amplified resist, 6 P-SiON film.

[Figure 4]



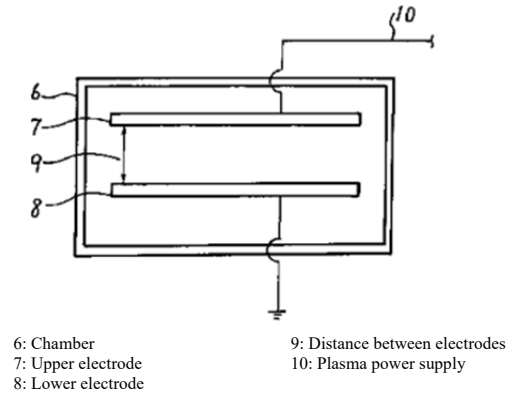
[Figure 1]



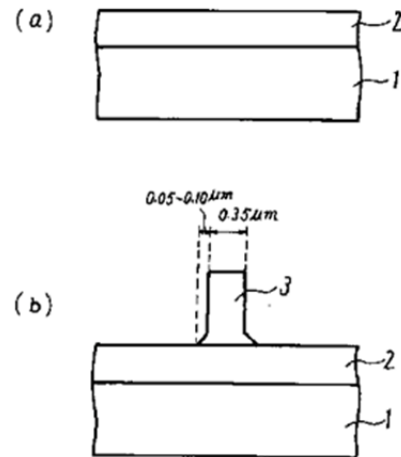
[Figure 3]

Plasma output (W)	Processing time (sec)	Distance between electrodes (mm)	Chamber pressure (Torr)	N ₂ O flow rate (l/min)	Thickness of oxide film (angstroms)
300	30	12.5	4.25	1	40
600	30	12.5	4.25	1	54
600	60	12.5	4.25	1	59
900	30	12.5	4.25	1	63
900	60	12.5	4.25	1	68
300	180	12.5	4.25	1	70
300	30	12.5	1.6	1	70
300	30	12.5	6.0	1	70
300	30	12.5	4.25	3	40
300	30	12.5	4.25	5	40
300	30	5	4.25	1	60
300	30	15	4.25	1	35

[Figure 2]



[Figure 5]



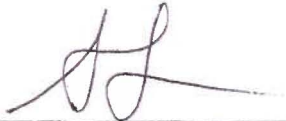
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Wendy Poon, Project Assistant

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