

Claims

1. (Currently Amended) An etching method comprising:

preparing a substrate having an etching target portion formed on a silicon-containing portion;

plasma-etching the etching target portion of the substrate into a predetermined pattern by plasma of a processing gas containing a CF-based gas; and

removing a damage layer formed due to implantation of C and F into the silicon-containing portion exposed at a bottom of the predetermined pattern by the plasma etching,

wherein said removing the damage layer includes

~~forming an oxide of the damage layer by supplying oxygen-containing radicals and fluorine-containing radicals, etching the damage layer with the fluorine-containing radicals and oxidizing a remaining~~ the damage layer with the oxygen-containing radicals to modify the remaining damage layer into an oxide~~while etching the damage layer with the fluorine-containing radicals~~; and

removing the oxide by a radical treatment or a chemical treatment with a gas.

2. (Original) The etching method of claim 1, wherein the etching target portion is a silicon oxide film.

3. (Currently Amended) The etching method of claim 1 or 2, wherein said etching the damage layer and said oxidizing the remaining damage layer

~~are said forming the oxide~~ is performed by using plasma generated by an oxygen-containing gas and a fluorine-containing gas.

4. (Currently Amended) The etching method of claim 3, wherein, in said etching the damage layer and said oxidizing the remaining damage layers~~said forming the oxide~~, the oxygen-containing gas contains O₂ gas, and the fluorine-containing gas contains NF₃ gas, SF₆ gas, or F₂ gas.

5. (Currently Amended) The etching method of claim 4, wherein, in said etching the damage layer and said oxidizing the remaining damage layers~~said forming the oxide~~, the oxygen-containing gas further contains H₂ gas.

6. (Original) The etching method of claim 4 or 5, wherein a volume ratio of the fluorine-containing gas to the oxygen-containing gas is 1% by volume (vol%) or less.

7. (Currently Amended) The etching method of any one of claims 3 to 6, wherein said etching the damage layer and said oxidizing the remaining damage layer~~are said forming the oxide~~ is performed by remote plasma that generates the plasma in a plasma generation space that is separate from a processing space where the substrate is placed.

8. (Currently Amended) The etching method of any one of claims 3 to 7, wherein said etching the damage layer and said oxidizing the remaining damage layer~~are said forming the oxide~~ is performed at a pressure in a range of 13.3 to 266.6 Pa and a temperature in a range of 0 to 120°C.

9. (Original) The etching method of any one of claims 1 to 8, wherein said removing the oxide is performed by the chemical treatment with a processing gas containing a fluorine-containing gas.

10. (Original) The etching method of claim 9, wherein the processing gas containing the fluorine-containing gas contains an H₂O gas or a reducing gas in addition to a fluorine-containing gas.

11. (Original) The etching method of claim 9 or 10, wherein the processing gas containing the fluorine-containing gas contains HF gas as the fluorine-containing gas and contains NH₃ gas as a reducing gas.

12. (Original) The etching method of claim 10 or 11, wherein said removing the oxide is performed at a pressure in a range of 6.66 to 400 Pa and a temperature in a range of 0 to 120°C.

13. (Original) The etching method of claim 11 or 12, wherein, in said removing the oxide, an ammonium fluoride-based compound produced after the chemical treatment is removed by heating.

14. (Original) The etching method of any one of claims 1 to 8, wherein said removing the oxide is performed by the radical treatment with F radicals and N radicals formed by activating a processing gas containing NF₃ gas and NH₃ gas.

15. (Currently Amended) The etching method of any one of claims 1 to 14, wherein a CF-based deposit remains as an etching residue after said plasma-etching is performed,

in said removing the damage layer, the CF-based deposit is removed together with the damage layer,

in said etching the damage layer and said oxidizing the remaining damage layersaid forming the oxide, an oxide of the CF-based deposit is formed together with the oxide of the damage layer, and

in said removing the oxide, the oxide of the CF-based deposit is also removed.

16. (Currently Amended) The etching method of any one of claims 1 to 15, wherein a photoresist layer used as an etching mask remains after said plasma-etching is performed, and the photoresist layer is removed by the oxygen-containing radicals of said etching the damage layer and said oxidizing the remaining damage layersaid forming the oxide.

17. (Original) The etching method of any one of claims 1 to 15, further comprising:

ashing and removing a photoresist layer used as an etching mask remaining after said plasma-etching is performed,

wherein said removing the damage layer is performed after said ashing and removing the photoresist layer is performed.

18. (Original) The etching method of claim 17, further comprising:

removing an ashing residue by a wet treatment after said ashing and

removing the photoresist layer is performed,

wherein said removing the damage layer is performed after said removing the ashing residue.

19. (Currently Amended) A method of removing a damage layer that is formed due to implantation of C and F into a silicon-containing portion exposed at a bottom of a predetermined pattern that is formed by etching a substrate having an etching target portion formed on the silicon-containing portion by plasma of a processing gas containing a CF-based gas, the method comprising:

~~forming an oxide of the damage layer by supplying oxygen-containing radicals and fluorine-containing radicals, etching the damage layer with the fluorine-containing radicals and oxidizing a remaining the damage layer with the oxygen-containing radicals— to modify the remaining damage layer into an oxide~~while etching the damage layer with the fluorine-containing radicals; and

removing the oxide by a radical treatment or a chemical treatment with a gas.

20. (Original) A computer-readable storage medium storing a computer executable program for controlling a processing system and the program, when executed by a computer, performs the etching method of any one of claims 1 to 18.