

WHAT IS CLAIMED IS:

1. A substrate processing method, comprising:

placing a substrate in a chamber, the substrate including a silicon-containing film and a mask on the silicon-containing film; and

5 generating plasma from a first process gas containing a hydrogen fluoride gas and a phosphorus-containing gas in the chamber and etching the silicon-containing film,

wherein a flow rate of the hydrogen fluoride gas is at least 25vol% of a total flow rate of non-inert components of the first process gas.
2. The substrate processing method according to claim 1, wherein

10 the flow rate of the hydrogen fluoride gas is less than 80vol% of the total flow rate of non-inert components of the first process gas.
3. The substrate processing method according to claim 1 or 2, wherein

the first process gas contains at least one selected from the group consisting of a carbon-containing gas, an oxygen-containing gas, and a halogen-containing gas.
- 15 4. The substrate processing method according to claim 3, wherein

the carbon-containing gas contains at least one selected from the group consisting of a fluorocarbon gas, a hydrofluorocarbon gas, and a hydrocarbon gas.
5. The substrate processing method according to claim 1 or 2, wherein the first process gas contains a halogen-containing gas.

6. The substrate processing method according to any one of claims 3 to 5, wherein the halogen-containing gas is at least one selected from the group consisting of SF₆, NF₃, XeF₂, SiF₄, IF₇, ClF₅, BrF₅, AsF₅, NF₅, PF₃, PF₅, POF₃, BF₃, HPF₆, WF₆, SiCl₂, SiCl₄, CCl₄, BCl₃, PCl₃, PCl₅, POCl₃, CBr₂F₂, C₂F₅Br, PBr₃, PBr₅, POBr₃, HI, CF₃I, C₂F₅I, C₃F₇I, IF₅, I₂, and
5 PI₃.

7. The substrate processing method according to any one of claims 3 to 5, wherein the halogen-containing gas is at least one selected from the group consisting of XeF₂, PF₃, PF₅, WF₆, BCl₃, PCl₃, PCl₅, POCl₃, CBr₂F₂, C₂F₅Br, CF₃I, C₂F₅I, and C₃F₇I.

8. The substrate processing method according to any one of claims 1 to 7, wherein the
10 first process gas contains at least one selected from the group consisting of O₂, CO, CO₂, H₂O and H₂O₂.

9. The substrate processing method according to any one of claims 1 to 8, wherein the first process gas includes a nitrogen-containing gas or a noble gas.

10. The substrate processing method according to any one of claims 1 to 9, wherein
15 the silicon-containing film includes at least one selected from the group consisting of a film stack including a silicon oxide film and a silicon nitride film, a polysilicon film, a film with a low dielectric constant, and a film stack including a silicon oxide film and a polysilicon film.

11. The substrate processing method according to any one of claims 1 to 10, wherein

the mask includes a carbon-containing mask, a metal-containing mask, or a boron-containing mask.

12. The substrate processing method according to claim 11, wherein

the carbon-containing mask comprises at least one selected from the group consisting of

5 spin-on carbon, tungsten carbide, amorphous carbon, and boron carbide.

13. The substrate processing method according to any one of claims 1 to 10, wherein the

mask is a metal-containing mask containing at least one selected from the group consisting of

titanium nitride, titanium oxide, and tungsten.

14. The substrate processing method according to any one of claims 1 to 13, further

10 comprising:

adjusting a temperature of an electrostatic chuck on which the substrate is placed to 0 °C or

lower before the generating plasma and the etching.

15. The substrate processing method according to any one of claims 1 to 14, further

comprising:

15 generating plasma from a second process gas in the chamber and cleaning an inside of the

chamber.

16. The substrate processing method according to claim 15, wherein

the second process gas contains at least one selected from the group consisting of a fluorine-containing gas, an oxygen-containing gas, a hydrogen-containing gas, and a nitrogen-containing gas.

17. A substrate processing method comprising:

5 placing a substrate in a chamber, the substrate including a silicon-containing film and a mask on the silicon-containing film;

generating plasma from a first process gas containing a hydrogen fluoride gas in the chamber and etching the silicon-containing film, and

10 generating plasma from a third process gas in the chamber and depositing a precoat film on an inner wall of the chamber before the placing the substrate,

wherein a flow rate of the hydrogen fluoride gas is at least 25vol% of a total flow rate of non-inert components of the first process gas.

18. The substrate processing method according to claim 17, wherein

the third process gas contains a silicon-containing gas and an oxygen-containing gas.

15 19. A plasma processing apparatus, comprising:

a chamber having a gas inlet and a gas outlet;

a plasma generator; and

a controller configured to cause

placing a substrate in the chamber, the substrate including a silicon-containing film and a mask on the silicon-containing film, and

generating plasma from a first process gas containing a hydrogen fluoride gas and a phosphorus-containing gas in the chamber and etching the silicon-containing film,

5 wherein the generating plasma and the etching include controlling a flow rate of the hydrogen fluoride gas to at least 25vol% of a total flow rate of non-inert components of the first process gas.