with plasma generated from a first gas that includes a fluorine-containing gas, to form an etching shape having a bottom; (c) generating plasma from a second gas that includes a hydrogen fluoride (HF) gas, to selectively form a condensed or solidified layer of HF at the bottom of the etching shape; and (d) etching the bottom with the plasma generated from the second gas, by supplying a bias power to the support. During (c) and (d), a temperature of the substrate may be maintained to be 0 °C or lower.

[0004a] In one aspect, there is provided an etching method comprising providing a substrate that contains silicon, on a support inside a chamber; setting a temperature of the substrate to 0 °C or lower; supplying an HF gas with a volume flow ratio of 30 % or more with respect to a total flow rate of a mixed gas, into the chamber; and etching the substrate with plasma generated from the mixed gas, by supplying a radio-frequency power, wherein during the supplying and the etching, the temperature of the substrate is maintained to be 0 °C or lower.

[0005] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a view illustrating an etching method according to an embodiment.

[0007] FIG. 2 is a view illustrating a flow of a second etching according to an embodiment.

[0008] FIGS. 3A to 3C are views illustrating a flow of an etching of an etching target film

[0009] FIGS. 4A to 4C are views illustrating the flow of the etching of the etching target film.

[0010] FIG. 5 is a schematic cross-sectional view illustrating an example of a plasma etching apparatus according to an embodiment.

DETAILED DESCRIPTION

[0011] In the following detailed description, reference is made to the accompanying drawing, which form a part hereof. The illustrative embodiments described in the

WHAT IS CLAIMED IS:

1. An etching method comprising:

(a) providing a substrate that contains silicon, on a support;

(b) etching the substrate with plasma generated from a first gas that includes a fluorine-containing gas, to form an etching shape having a bottom;

(c) generating plasma from a second gas that includes a hydrogen fluoride (HF) gas, to selectively form a condensed or solidified layer of HF at the bottom of the etching shape; and

(d) etching the bottom with the plasma generated from the second gas, by supplying a bias power to the support,

wherein during (c) and (d), a temperature of the substrate is maintained to be 0 °C or lower.

2. The etching method according to claim 1, wherein (c) and (d) are performed at the same time.

3. The etching method according to claim 1 or 2, wherein (c) and (d) are performed when an opening diameter of the etching shape is 200 nm or less, and an aspect ratio is 20 or more.

4. The etching method according to any one of claims 1 to 3, wherein after (a), the temperature of the substrate is set to -40 °C or lower.

5. The etching method according to any one of claims 1 to 4, wherein (d) etches

the bottom with the plasma generated from the second gas or plasma generated from a rare gas.

6. The etching method according to any one of claims 1 to 5, wherein the etching is performed by attracting ions in the plasma generated from the second gas into the bottom, and causing the condensed or solidified layer that has been formed at the bottom to react with the bottom.

7. An etching method comprising:

providing a substrate that contains silicon, on a support inside a chamber;

setting a temperature of the substrate to 0 °C or lower;

supplying an HF gas with a volume flow ratio of 30 % or more with respect to a total flow rate of a mixed gas, into the chamber; and

etching the substrate with plasma generated from the mixed gas, by supplying a radio-frequency power,

wherein during the supplying and the etching, the temperature of the substrate is maintained to be 0 °C or lower.

8. The etching method according to claim 7, wherein the setting sets the temperature of the substrate to -40 °C or lower, and

during the supplying and the etching, the temperature of the substrate is maintained to be 0 °C or lower.

9. The etching method according to any one of claims 1 to 8, wherein the substrate that contains silicon includes a silicon oxide film or a silicon nitride film.

10. The etching method according to any one of claims 1 to 8, wherein the substrate that contains silicon includes a stacked film of a silicon oxide film and a silicon nitride film.

11. The etching method according to any one of claims 1 to 8, wherein the substrate that contains silicon includes a stacked film of a silicon oxide film and polysilicon.