unsaturated bond.

[0003a] In one aspect, the present disclosure provides an etching method comprising (a) providing a substrate on a substrate support inside a chamber, the substrate including a first region having a multilayer film in which a silicon oxide film and a silicon nitride film are alternately stacked and a second region having a monolayer silicon oxide film; and (b) etching the substrate with plasma generated from a first processing gas that includes a hydrofluorocarbon gas, wherein the hydrofluorocarbon gas includes a first hydrofluorocarbon gas represented by CxHyFz (x represents an integer of 2 or more, and y and z represent an integer of 1 or more) and having an unsaturated bond and a second hydrofluorocarbon gas different from the first hydrofluorocarbon gas; and a flow ratio of the first hydrofluorocarbon gas to the second hydrofluorocarbon gas is 0.3 or more and 0.5 or less.

[0003b] In another aspect, the present disclosure provides an etching method comprising (a) providing a substrate on a substrate support inside a chamber, the substrate including a first region having a multilayer film in which a silicon oxide film and a silicon nitride film are alternately stacked and a second region having a monolayer silicon oxide film; (b) etching the substrate with plasma generated from a first processing gas that includes a hydrofluorocarbon gas; and c) etching the substrate with plasma generated from a second processing gas that includes a fluorocarbon gas, wherein the hydrofluorocarbon gas includes a first hydrofluorocarbon gas represented by CxHyFz (x represents an integer of 2 or more, and y and z represent an integer of 1 or more) and having an unsaturated bond, (b) and (c) are alternately repeated, and a ratio of the processing time in (b) to the processing time in (c) is 2 or more and 3 or less.

[0003c] In yet another aspect, the present disclosure provides an etching method comprising (a) providing a substrate on a substrate support inside a chamber, the

substrate including a first region having a multilayer film in which a silicon oxide film and a silicon nitride film are alternately stacked and a second region having a monolayer silicon oxide film; (b) etching the substrate with plasma generated from a first processing gas that includes a hydrofluorocarbon gas; and (c) etching the substrate with plasma generated from a second processing gas that includes a fluorocarbon gas, wherein the hydrofluorocarbon gas includes a first hydrofluorocarbon gas represented by CxHyFz (x represents an integer of 2 or more, and y and z represent an integer of 1 or more) and having an unsaturated bond, and a ratio of the processing time in (b) to the processing time in (c) is 2 or more and 3 or less.

[0003d] In another aspect, the present disclosure provides an etching processing apparatus comprising a processing chamber; a substrate support provided inside the processing chamber to hold a substrate; a gas supply configured to supply a first processing gas into the processing chamber; a plasma generator configured to generate plasma from the first processing gas; and a controller, wherein the controller controls the gas supply and the plasma generator and performs a process including (a) providing the substrate on the substrate support inside a chamber, the substrate including a first region having a multilayer film in which a silicon oxide film and a silicon nitride film are alternately stacked and a second region having a monolayer silicon oxide film, and (b) etching the substrate with plasma generated from the first processing gas that includes a hydrofluorocarbon gas, and the controller controls the etching process such that the first processing gas includes a first hydrofluorocarbon gas represented by CxHyFz (x represents an integer of 2 or more, and y and z represent an integer of 1 or more) and having an unsaturated bond and a second hydrofluorocarbon gas different from the first hydrofluorocarbon gas, and a flow ratio of the first hydrofluorocarbon gas to the second hydrofluorocarbon gas is 0.3 or more and 0.5 or less.

[0003e] In yet another aspect, there is provided an etching processing apparatus comprising a processing chamber; a substrate support provided inside the processing chamber to hold a substrate; a gas supply configured to supply a first processing gas into the processing chamber; a plasma generator configured to generate plasma from the first processing gas; and a controller, wherein the controller controls the gas supply and the plasma generator and performs a process including (a) providing the substrate on the substrate support inside a chamber, the substrate including a first region having a multilayer film in which a silicon oxide film and a silicon nitride film are alternately stacked and a second region having a monolayer silicon oxide film, (b) etching the substrate with plasma generated from the first processing gas that includes a hydrofluorocarbon gas, and (c) etching the substrate with plasma generated from a second processing gas that includes a fluorocarbon gas, the controller controls the etching process such that the hydrofluorocarbon gas includes a first hydrofluorocarbon gas represented by CxHyFz (x represents an integer of 2 or more, and y and z represent an integer of 1 or more) and having an unsaturated bond, (b) and (c) are alternately repeated, and a ratio of the processing time in (b) to the processing time in (c) is 2 or more and 3 or less.

[0004] According to the present disclosure, an etching shape having a high aspect ratio can be appropriately formed.

[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 vertical sectional view schematically illustrating an example of a configuration of a plasma processing system.

[0007] FIGS. 2A and 2B are explanatory views illustrating an example of an etching target layer formed on a surface of a substrate.

[0008] FIG. 3 is a flow chart illustrating main steps of a plasma processing according to an embodiment.

[0009] FIG. 4 is an explanatory view illustrating an example of a structural formula of a $C_3H_2F_4$ gas.

[0010] FIG. 5 is an explanatory view illustrating an example of an etching process result according to an example.

[0011] FIG. 6 is an explanatory view illustrating an example of an etching process result according to an example.

[0012] FIG. 7 is an explanatory view illustrating an example of an etching process result according to an example.

[0013] FIG. 8 is an explanatory view illustrating an example of an etching process

WHAT IS CLAIMED IS:

1. An etching method comprising:

(a) providing a substrate on a substrate support inside a chamber, the substrate including a first region having a multilayer film in which a silicon oxide film and a silicon nitride film are alternately stacked and a second region having a monolayer silicon oxide film; and

(b) etching the substrate with plasma generated from a first processing gas that includes a hydrofluorocarbon gas,

wherein the hydrofluorocarbon gas includes a first hydrofluorocarbon gas represented by CxHyFz (x represents an integer of 2 or more, and y and z represent an integer of 1 or more) and having an unsaturated bond and a second hydrofluorocarbon gas different from the first hydrofluorocarbon gas; and

a flow ratio of the first hydrofluorocarbon gas to the second hydrofluorocarbon gas is 0.3 or more and 0.5 or less.

2. The etching method according to claim 1, wherein the second hydrofluorocarbon gas does not have an unsaturated bond.

3. The etching method according to claim 1 or 2, wherein the second hydrofluorocarbon gas has a molecular weight smaller than a molecular weight of the first hydrofluorocarbon gas.

4. The etching method according to any one of claims 1 to 3, wherein the second

hydrofluorocarbon gas is at least one selected from the group consisting of CH_2F_2 gas and CHF_3 gas.

5. An etching method comprising:

(a) providing a substrate on a substrate support inside a chamber, the substrate including a first region having a multilayer film in which a silicon oxide film and a silicon nitride film are alternately stacked and a second region having a monolayer silicon oxide film;

(b) etching the substrate with plasma generated from a first processing gas that includes a hydrofluorocarbon gas; and

(c) etching the substrate with plasma generated from a second processing gas that includes a fluorocarbon gas,

wherein the hydrofluorocarbon gas includes a first hydrofluorocarbon gas represented by CxHyFz (x represents an integer of 2 or more, and y and z represent an integer of 1 or more) and having an unsaturated bond,

(b) and (c) are alternately repeated, and

a ratio of the processing time in (b) to the processing time in (c) is 2 or more and 3 or less.

6. An etching method comprising:

(a) providing a substrate on a substrate support inside a chamber, the substrate including a first region having a multilayer film in which a silicon oxide film and a silicon nitride film are alternately stacked and a second region having a monolayer silicon oxide film;

(b) etching the substrate with plasma generated from a first processing gas that includes a hydrofluorocarbon gas; and

(c) etching the substrate with plasma generated from a second processing gas that includes a fluorocarbon gas,

wherein the hydrofluorocarbon gas includes a first hydrofluorocarbon gas represented by CxHyFz (x represents an integer of 2 or more, and y and z represent an integer of 1 or more) and having an unsaturated bond, and

a ratio of the processing time in (b) to the processing time in (c) is 2 or more and 3 or less.

7. The etching method according to claim 5 or 6, wherein the second processing gas does not include the first hydrofluorocarbon gas or includes the first hydrofluorocarbon gas at a flow ratio different from a flow ratio of the first hydrofluorocarbon gas to a total flow rate of the first processing gas.

8. The etching method according to any one of claims 5 to 7, wherein the second processing gas includes a third hydrofluorocarbon gas different from the first hydrofluorocarbon gas.

9. The etching method according to claim 8, wherein the third hydrofluorocarbon gas does not have an unsaturated bond and has a molecular weight smaller than a molecular weight of the first hydrofluorocarbon gas.

10. The etching method according to any one of claims 1 to 9, wherein the first

hydrofluorocarbon gas has a fluoromethyl group (-CFx).

11. The etching method according to any one of claim 1 to 10, wherein the first hydrofluorocarbon gas is $C_3H_2F_4$ gas.

12. The etching method according to any one of claims 1 to 11, wherein the first processing gas further includes a fluorocarbon gas.

13. The etching method according to claim 12, wherein the fluorocarbon gas is at least one selected from the group consisting of C_4F_6 gas, CF_4 gas, C_4F_8 gas, and C_3F_8 gas.

14. The etching method according to any one of claims 1 to 13, the first processing gas further includes at least one selected from the group consisting of CO gas, COS gas, O_2 gas, NF_3 gas, and SF_6 gas.

15. The etching method according to any one of claims 1 to 14, wherein in (b), high frequency power for bias of 20 kW or more is supplied to the substrate support.

16. The etching method according to any one of claims 1 to 15, wherein a surface of the substrate has an organic or boron-based mask.

17. An etching processing apparatus comprising:

a processing chamber;

a substrate support provided inside the processing chamber to hold a substrate;

a gas supply configured to supply a first processing gas into the processing chamber;

a plasma generator configured to generate plasma from the first processing gas; and

a controller,

wherein the controller controls the gas supply and the plasma generator and performs a process including

(a) providing the substrate on the substrate support inside a chamber, the substrate including a first region having a multilayer film in which a silicon oxide film and a silicon nitride film are alternately stacked and a second region having a monolayer silicon oxide film, and

(b) etching the substrate with plasma generated from the first processing gas that includes a hydrofluorocarbon gas, and

the controller controls the etching process such that the first processing gas includes a first hydrofluorocarbon gas represented by CxHyFz (x represents an integer of 2 or more, and y and z represent an integer of 1 or more) and having an unsaturated bond and a second hydrofluorocarbon gas different from the first hydrofluorocarbon gas, and

a flow ratio of the first hydrofluorocarbon gas to the second hydrofluorocarbon gas is 0.3 or more and 0.5 or less.

18. An etching processing apparatus comprising:

a processing chamber;

a substrate support provided inside the processing chamber to hold a substrate;

a gas supply configured to supply a first processing gas into the processing chamber;

a plasma generator configured to generate plasma from the first processing gas; and

a controller,

wherein the controller controls the gas supply and the plasma generator and performs a process including

(a) providing the substrate on the substrate support inside a chamber, the substrate including a first region having a multilayer film in which a silicon oxide film and a silicon nitride film are alternately stacked and a second region having a monolayer silicon oxide film,

(b) etching the substrate with plasma generated from the first processing gas that includes a hydrofluorocarbon gas, and

(c) etching the substrate with plasma generated from a second processing gas that includes a fluorocarbon gas,

the controller controls the etching process such that the hydrofluorocarbon gas includes a first hydrofluorocarbon gas represented by CxHyFz (x represents an integer of 2 or more, and y and z represent an integer of 1 or more) and having an unsaturated bond,

(b) and (c) are alternately repeated, and

a ratio of the processing time in (b) to the processing time in (c) is 2 or more and 3 or less.