

ETCHING METHOD AND PLASMA PROCESSING APPARATUS

TECHNICAL FIELD

[0001] The various aspects and embodiments described herein pertain generally to an etching method and a plasma processing apparatus.

BACKGROUND

[0002] Patent Document 1, for example, proposes etching a stacked film including a silicon oxide film and a silicon nitride film by plasma formed in a low-temperature environment equal to or less than -30°C.

[0003] Patent Document 1: Japanese Patent Laid-open Publication No. 2016-207840

SUMMARY

[0004] ~~In one exemplary embodiment~~According to a first aspect of the present invention, there is provided an etching method of forming, on a substrate having a base film; a stacked film in which a first film and a second film are alternately stacked on the base film; and a mask on the stacked film, a recess in the stacked film through the mask by using plasma. The etching method includes preparing the substrate; and etching the stacked film until the recess of the stacked film reaches the base film by plasma formed from a gas containing hydrogen, fluorine and carbon, while maintaining a substrate temperature equal to or less than 15°C, wherein a ratio of the hydrogen to a sum of the hydrogen, the fluorine and the carbon included in the gas is in a range from 0.02 to 0.06.

[0004a] According to a second aspect of the present invention, there is provided an etching method of forming, on a substrate having a base film; a stacked film in which a first film and a second film are alternately stacked on the base film; and a mask on the stacked film, a recess in the stacked film through the mask by using plasma, the etching method comprising:

preparing the substrate; and

etching the stacked film until the recess of the stacked film reaches the base film by plasma formed from a gas containing hydrogen, fluorine and carbon, while maintaining a substrate temperature equal to or less than 15°C,

wherein a ratio of the fluorine to a sum of the hydrogen, the fluorine and the carbon included in the gas is in a range from 0.63 to 0.65.

The foregoing summary is illustrative only and is not intended to be any way limiting. In addition to the illustrative ~~aspects~~ examples, embodiments, and features described above, further ~~aspects~~ examples,

WE CLAIM

1. An etching method of forming, on a substrate having a base film; a stacked film in which a first film and a second film are alternately stacked on the base film; and a mask on the stacked film, a recess in the stacked film through the mask by using plasma, the etching method comprising:

preparing the substrate; and

etching the stacked film until the recess of the stacked film reaches the base film by plasma formed from a gas containing hydrogen, fluorine and carbon, while maintaining a substrate temperature equal to or less than 15°C,

wherein a ratio of the hydrogen to a sum of the hydrogen, the fluorine and the carbon included in the gas is in a range from 0.02 to 0.06.

~~2. The etching method of Claim 1,~~

~~wherein a ratio of the hydrogen to a sum of the hydrogen, the fluorine and the carbon included in the gas is in a range from 0.02 to 0.06.~~

~~32. The etching method of Claim 1 or 2,~~An etching method of forming, on a substrate having a base film; a stacked film in which a first film and a second film are alternately stacked on the base film; and a mask on the stacked film, a recess in the stacked film through the mask by using plasma, the etching method comprising:

preparing the substrate; and

etching the stacked film until the recess of the stacked film reaches the base film by plasma formed from a gas containing hydrogen, fluorine and carbon, while maintaining a substrate temperature equal to or less than 15°C,

wherein a ratio of the fluorine to a sum of the hydrogen, the fluorine and the carbon included in the gas is in a range from 0.63 to 0.65.

43. The etching method of ~~any one of Claims 1 to 3~~,

wherein the gas includes at least one of a fluorocarbon gas (CF-based gas) or a hydrofluorocarbon gas (CHF-based gas), and at least one of a hydrofluorocarbon gas (CHF-based gas), hydrocarbon gas (CH-based gas) or a hydrogen-containing gas, and

the hydrogen-containing gas is a hydrogen gas or hydrogen halide.

54. The etching method of ~~any one of Claims 1 to 4~~, further comprising:

etching the stacked film until the recess of the stacked film reaches a preset depth before the etching of the stacked film until the recess of the stacked film reaches the base film.

65. The etching method of Claim 54,

wherein the preset depth of the recess is equal to or larger than 40 in aspect ratio.

76. The etching method of Claim 54,

wherein a substrate temperature in the etching of the stacked film until the recess of the stacked film reaches a preset depth is equal to the substrate temperature in the etching of the stacked film until the recess of the stacked film reaches the base film.

~~87.~~ The etching method ~~of any one~~ of Claims ~~1 to 7~~,
wherein the gas further includes a halogen-containing gas other than fluorine.

~~98.~~ The etching method ~~of any one~~ of Claims ~~1 to 8~~,
wherein the first film is a silicon oxide film, and the second film is a silicon nitride film.

~~109.~~ The etching method ~~of any one~~ of Claims ~~1 to 9~~,
wherein the base film is one of polysilicon, amorphous silicon, and single crystal silicon.

~~11. — A plasma processing apparatus comprising a controller configured to control an etching processing of forming, on a substrate having a base film, a stacked film in which a first film and a second film are alternately stacked on the base film, and a mask on the stacked film, a recess in the stacked film through the mask by using plasma,~~
~~wherein the controller controls:~~
~~preparing the substrate; and~~
~~etching the stacked film by plasma of a gas containing hydrogen, fluorine and carbon, until the recess of the stacked film reaches the base film, while maintaining a substrate temperature equal to or less than 15°C.~~

10. The etching method of Claim 1,
wherein the mask is made of an organic material.

11. The etching method of Claim 1,
a ratio of the fluorine to a sum of the hydrogen, the fluorine and the carbon included in
the gas is in a range from 0.63 to 0.65.

12. The etching method of Claim 1,
wherein the gas includes a first gas and a second gas different from the first gas,
the first gas includes at least one of a fluorocarbon gas (CF-based gas) or a
hydrofluorocarbon gas (CHF-based gas), and
the second gas includes at least one of a hydrofluorocarbon gas (CHF-based gas),
hydrocarbon gas (CH-based gas) or a hydrogen-containing gas.

13. The etching method of Claim 12,
wherein the hydrogen-containing gas is a hydrogen gas or hydrogen halide.

14. The etching method of Claim 12,
wherein the hydrofluorocarbon gas included in the first gas and the second gas is at least
one of a CH_2F_2 gas, a CHF_3 gas, or a $\text{C}_3\text{H}_2\text{F}_4$ gas.

15. The etching method of Claim 12,
wherein the fluorocarbon gas included in the first gas is at least one of a C_4F_8 gas, a C_4F_6 gas,
or a CF_4 gas.

16. The etching method of Claim 12,

wherein the hydrocarbon gas included in the second gas is at least one of a CH₄ gas, a C₂H₆ gas, or a C₂H₄ gas.

17. The etching method of Claim 7,
wherein the halogen-containing gas other than fluorine is at least one of a SiCl₄ gas, Cl₂ gas,
a HBr gas, a HCl gas, a HI gas, a Br₂ gas, or a CF₂Br₂ gas.

18. The etching method of Claim 1,
wherein the gas further includes an oxygen-containing gas.

19. The etching method of Claim 1,
wherein the etching the stacked film comprises:
a main etching of etching the stacked film until the recess of the stacked film reaches a
preset depth; and
after the main etching, an over etching of etching the stacked film until the recess of the
stacked film reaches the base film.

20. The etching method of Claim 19,
wherein the main etching and the over etching are performed in a same plasma processing
apparatus consecutively.