

METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE, METHOD OF PROCESSING SUBSTRATE, SUBSTRATE PROCESSING APPARATUS, AND PROGRAM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2019-211137, filed on November 22, 2019, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to a method of manufacturing a semiconductor device, a substrate processing apparatus, and a program.

BACKGROUND

[0003] In the related art, as a process of manufacturing a semiconductor device, a process of etching a base exposed on a surface of a substrate is carried out.

SUMMARY

[0004] Some embodiments of the present disclosure provide a technique capable of enhancing etching controllability.

[0005] According to an embodiment of the present disclosure, there is provided a technique that includes: etching a base exposed on a surface of a substrate by performing a cycle a predetermined number of times, the cycle including non-simultaneously performing: (a) forming a modified layer on a surface of the base by supplying a modifying agent to the base; and (b) causing a reaction between a halogen-containing radical and the base by supplying a halogen-containing gas to the modified layer such that the modified layer reacts with the halogen-containing gas to generate the halogen-containing radical.

WHAT IS CLAIMED IS:

1. A method of manufacturing a semiconductor device, comprising:
etching a base exposed on a surface of a substrate by performing a cycle a predetermined number of times, the cycle including non-simultaneously performing:
 - (a) forming a modified layer on a surface of the base by supplying a modifying agent including a silicon-containing gas to the base and adsorbing silicon contained in the silicon-containing gas on the surface of the base; and
 - (b) causing a reaction between a halogen-containing radical and the base by supplying a halogen-containing gas to the modified layer such that the modified layer reacts with the halogen-containing gas to generate the halogen-containing radical, wherein in (a), the modifying agent is supplied under a condition in which the silicon-containing gas is not gas-phase decomposed and the adsorption of the silicon on the surface of the base is saturated.
2. The method according to Claim 1, wherein in (b), the halogen-containing gas is supplied under a condition in which an amount of the halogen-containing gas that reacts with the modified layer in the reaction between the halogen-containing gas and the modified layer is larger than an amount of the halogen-containing gas that reacts with the base in the reaction between the halogen-containing gas and the base.
3. The method according to Claim 1, wherein in (b), the halogen-containing gas is supplied under a condition in which the reaction between the halogen-containing gas and the modified layer proceeds and the reaction between the halogen-containing gas and the base does not proceed.
4. The method according to Claim 1, wherein in (b), the base is etched with the halogen-containing radical generated by the reaction between the halogen-containing gas and the

modified layer.

5. The method according to Claim 4, wherein in (b), the halogen-containing gas is supplied under a condition in which an amount of the halogen-containing radical that reacts with the base in the reaction between the halogen-containing radical and the base is larger than an amount of the halogen-containing gas that reacts with the base in the reaction between the halogen-containing gas and the base.

6. The method according to Claim 4, wherein in (b), the halogen-containing gas is supplied under a condition in which the reaction between the halogen-containing radical and the base proceeds and the reaction between the halogen-containing gas and the base does not proceed.

7. The method according to Claim 1, wherein the modifying agent includes aminosilane, and
wherein in (a), silicon contained in the aminosilane is adsorbed on the surface of the base.

8. The method according to Claim 1, wherein in (a), the modifying agent is supplied under a condition in which the adsorption of the silicon on the surface of the base is self-limited.

9. The method according to Claim 1, wherein the cycle further includes (c) pre-processing the surface of the base before performing (a).

10. The method according to Claim 9, wherein in (c), an adsorption site is formed on the surface of the base.

11. The method according to Claim 1, wherein the cycle further includes (c) OH-terminating the surface of the base before performing (a).

12. The method according to Claim 9, wherein in (c), a gas containing oxygen and hydrogen is supplied to the substrate.

13. The method according to Claim 1, wherein the halogen-containing gas includes at least one selected from the group of a fluorine-containing gas, a chlorine-containing gas, and an iodine-containing gas.

14. The method according to Claim 1, wherein the halogen-containing radical includes at least one selected from the group of a fluorine-containing radical, a chlorine-containing radical, and an iodine-containing radical.

15. The method according to Claim 1, wherein the base contains at least one selected from the group of a semi-metal element and a metal element.

16. A substrate processing apparatus, comprising:
a process chamber in which a substrate is processed;
a modifying agent supply system configured to supply a modifying agent including a silicon-containing gas to the substrate in the process chamber;
a halogen-containing gas supply system configured to supply a halogen-containing gas to the substrate in the process chamber; and
a controller configured to be capable of controlling the modifying agent supply system and the halogen-containing gas supply system to perform a process in the process chamber, the process comprising:

etching a base exposed on a surface of the substrate by performing a cycle a predetermined number of times, the cycle including non-simultaneously performing:

(a) forming a modified layer on a surface of the base by supplying the modifying agent to the base and adsorbing silicon contained in the silicon-containing gas on the surface of the base; and

(b) causing a reaction between a halogen-containing radical and the base by supplying the halogen-containing gas to the modified layer such that the modified layer reacts with the halogen-containing gas to generate the halogen-containing radical,

wherein in (a), the modifying agent is supplied under a condition in which the silicon-containing gas is not gas-phase decomposed and the adsorption of the silicon on the surface of the base is saturated.

17. A program that causes, by a computer, a substrate processing apparatus to perform a process in a process chamber of the substrate processing apparatus, the process comprising:
etching a base exposed on a surface of a substrate by performing a cycle a predetermined number of times, the cycle including non-simultaneously performing:

(a) forming a modified layer on a surface of the base by supplying a modifying agent including a silicon-containing gas to the base and adsorbing silicon contained in the silicon-containing gas on the surface of the base; and

(b) causing a reaction between a halogen-containing radical and the base by supplying a halogen-containing gas to the modified layer such that the modified layer reacts with the halogen-containing gas to generate the halogen-containing radical,
wherein in (a), the modifying agent is supplied under a condition in which the silicon-containing gas is not gas-phase decomposed and the adsorption of the silicon on the surface of the base is saturated.

18. A method of processing a substrate, comprising:
etching a base exposed on the surface of the substrate by performing a cycle a predetermined number of times, the cycle including non-simultaneously performing:

(a) forming a modified layer on a surface of the base by supplying a modifying agent including a silicon-containing gas to the base and adsorbing silicon contained in the silicon-containing gas on the surface of the base; and

(b) causing a reaction between a halogen-containing radical and the base by supplying a halogen-containing gas to the modified layer such that the modified layer reacts with the halogen-containing gas to generate the halogen-containing radical, wherein in (a), the modifying agent is supplied under a condition in which the silicon-containing gas is not gas-phase decomposed and the adsorption of the silicon on the surface of the base is saturated.