SUBSTRATE PROCESSING METHOD, METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE, 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. 2020-164643, filed on September 30, 2020, 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 method, a substrate processing apparatus, and a program.

BACKGROUND

[0003] As a process of manufacturing a semiconductor device, a film-forming process of forming a film on a substrate in a process container may be performed. When performing the film-forming process, a film is also formed inside the process container. By repeating the film-forming process, the film is cumulatively deposited inside the process container. If the thickness of the cumulative film formed inside the process container exceeds a critical film thickness, cracks and film peeling occur in the film, thereby generating particles and leading to contamination of foreign substances. For that reason, the interior of the process container may be regularly cleaned to remove the cumulative film. However, during the cleaning, the film-forming process cannot be performed. If a cleaning frequency is high, that is, if the cleaning cycle is short, the productivity of the film-forming process may decrease.

SUMMARY

[0004] Some embodiments of the present disclosure provide a technique capable of prolonging the cleaning cycle and improving the productivity of a film-forming process by properly

WHAT IS CLAIMED IS:

1. A substrate processing method, comprising:

(a) loading a substrate into a process container;

(b) performing a process of forming a nitride film on the substrate in the process container by alternately or simultaneously performing, a predetermined number of times:

supplying a precursor gas from a first supplier to the substrate; and

supplying a nitriding gas from a second supplier to the substrate;

(c) unloading the processed substrate from an interior of the process container; and

(d) oxidizing at least one part of a nitride film formed inside the process container in (b) so as to change the at least one part into an oxide film in a state in which the processed substrate is unloaded from the interior of the process container,

wherein in (d), an oxygen-containing gas and a hydrogen-containing gas are supplied into the process container and at that time, the hydrogen-containing gas is supplied toward the first supplier.

2. The method of Claim 1, wherein in (d), the hydrogen-containing gas is supplied from a position facing the first supplier toward the first supplier.

3. The method of Claim 1 or 2, wherein in (d), an oxidization amount of a nitride film, which is formed on the first supplier and a periphery of the first supplier inside the process container, is made larger than an oxidization amount of a nitride film, which is formed on other parts inside the process container.

4. The method of Claim 1 or 2, wherein in (d), an oxide film, which is formed by oxidizing a nitride film formed on the first supplier and a periphery of the first supplier inside the process container, is made thicker than an oxide film formed by oxidizing a nitride film, which is formed

on other parts inside the process container.

5. The method of Claim 1 or 2, wherein in (b), a nitride film, which is formed on the first supplier and a periphery of the first supplier inside the process container, is thicker than a nitride film, which is formed on other parts inside the process container.

6. The method of any one of Claims 1 to 5, wherein the second supplier is installed in a plural number, and

wherein in (d), the oxygen-containing gas and the hydrogen-containing gas are supplied from any of the plurality of second suppliers.

7. The method of Claim 6, wherein one of the plurality of second suppliers faces the first supplier, and

wherein in (d), the hydrogen-containing gas is supplied from the second supplier, which faces the first supplier, toward the first supplier.

8. The method of any one of Claims 1 to 7, wherein (d) includes alternately performing, a predetermined number of times, stopping an exhaust of the interior of the process container and exhausting the interior of the process container in a state in which the oxygen-containing gas and the hydrogen-containing gas are continuously or intermittently supplied into the process container.

9. The method of any one of Claims 1 to 8, wherein (d) includes alternately performing:

supplying the oxygen-containing gas and the hydrogen-containing gas into the process container in a state in which an exhaust of the interior of the process container is stopped; and

supplying the oxygen-containing gas and the hydrogen-containing gas into the process container in a state in which the interior of the process container is exhausted.

10. The method of Claim 8, wherein in (d), a time for maintaining a state in which the exhaust of the interior of the process container is stopped is made longer than a time for maintaining a state in which the interior of the process container is exhausted.

11. The method of any one of Claims 1 to 7, 9 and 10, wherein (d) includes performing opening and closing an exhaust valve installed at an exhaust pipe, which is configured to exhaust the interior of the process container, a predetermined number of times in a state in which the oxygen-containing gas and the hydrogen-containing gas are continuously or intermittently supplied into the process container.

12. The method of any one of Claims 1 to 11, wherein (d) includes alternately performing, a predetermined number of times:

supplying the oxygen-containing gas and the hydrogen-containing gas into the process container in a state in which an exhaust valve installed at an exhaust pipe configured to exhaust the interior of the process container is closed; and

supplying the oxygen-containing gas and the hydrogen-containing gas into the process container in a state in which the exhaust valve is opened.

13. The method of Claim 11, wherein in (d), a time for maintaining a state in which the exhaust valve is closed is made longer than a time for maintaining a state in which the exhaust valve is opened.

14. The method of any one of Claims 1 to 7, 9, 10, 12 and 13, wherein in (d), the interior of the process container is pulse-exhausted in a state in which the oxygen-containing gas and the hydrogen-containing gas are continuously or intermittently supplied into the process container.

15. The method of any one of Claims 1 to 13, wherein in (d), the oxygen-containing gas and the hydrogen-containing gas are supplied into the process container which is in a heated state and at a pressure below an atmospheric pressure.

16. The method of any one of Claims 1 to 15, wherein in (d), a supply flow rate of the hydrogen-containing gas is made larger than a supply flow rate of the oxygen-containing gas.

17. The method of Claim 1, wherein the nitride film is a film containing at least one selected from the group of a semiconductor element and a metal element, and nitrogen.

18. A method of manufacturing a semiconductor device, comprising:

(a) loading a substrate into a process container;

(b) performing a process of forming a nitride film on the substrate in the process container by alternately or simultaneously performing, a predetermined number of times:

supplying a precursor gas from a first supplier to the substrate; and

supplying a nitriding gas from a second supplier to the substrate;

(c) unloading the processed substrate from an interior of the process container; and

(d) oxidizing at least one part of a nitride film formed inside the process container in (b) so as to change the at least one part into an oxide film in a state in which the processed substrate is unloaded from the interior of the process container,

wherein in (d), an oxygen-containing gas and a hydrogen-containing gas are supplied into the process container and at that time, the hydrogen-containing gas is supplied toward the first supplier.

19. A substrate processing apparatus, comprising:

a process container in which a substrate is processed;

a precursor gas supply system configured to supply a precursor gas from a first supplier

to the substrate in the process container;

a nitriding gas supply system configured to supply a nitriding gas from a second supplier to the substrate in the process container;

an oxygen-containing gas supply system configured to supply an oxygen-containing gas into the process container;

a hydrogen-containing gas supply system configured to supply a hydrogen-containing gas into the process container;

a transporter configured to transport the substrate into and out of the process container; and

a controller configured to be capable of controlling the precursor gas supply system, the nitriding gas supply system, the oxygen-containing gas supply system, the hydrogen-containing gas supply system, and the transporter so as to perform:

(a) loading the substrate into the process container;

(b) performing a process of forming a nitride film on the substrate in the process container by alternately or simultaneously performing, a predetermined number of times:

supplying the precursor gas from the first supplier to the substrate; and

supplying the nitriding gas from the second supplier to the substrate;

(c) unloading the processed substrate from an interior of the process container; and

(d) oxidizing at least one part of a nitride film formed inside the process container in (b) so as to change the at least one part into an oxide film in a state in which the processed substrate is unloaded from the interior of the process container,

wherein in (d), the oxygen-containing gas and the hydrogen-containing gas are supplied into the process container and at that time, the hydrogen-containing gas is supplied toward the first supplier.

20. A program that causes, by a computer, a substrate processing apparatus to perform:

(a) loading a substrate into a process container;

(b) performing a process of forming a nitride film on the substrate in the process container by alternately or simultaneously performing, a predetermined number of times:

supplying a precursor gas from a first supplier to the substrate; and

supplying a nitriding gas from a second supplier to the substrate;

(c) unloading the processed substrate from an interior of the process container; and

(d) oxidizing at least one part of a nitride film formed inside the process container in (b) so as to change the at least one part into an oxide film in a state in which the processed substrate is unloaded from the interior of the process container,

wherein in (d), an oxygen-containing gas and a hydrogen-containing gas are supplied into the process container and at that time, the hydrogen-containing gas is supplied toward the first supplier.