METHOD OF PROCESSING SUBSTRATE, METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE, ~~SUBSTRATE PROCESSING METHOD,~~ 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. 2020-112463, filed on June 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] In the related art, as a process of manufacturing a semiconductor device, a film-forming process of forming a film such as a nitride film on a substrate in a process container may be performed. When performing the film-forming process, a film is also formed in the process container. By repeating the film-forming process, the film is cumulatively deposited in the process container. The cumulative film formed in the process container is cracked or peeled off as the thickness thereof exceeds a critical film thickness. Thus, particles are generated, which may be a cause of foreign substance contamination. For this reason, the interior of the process container may be periodically cleaned to remove the cumulative film. However, during the cleaning, the film-forming process cannot be performed. In a case where a cleaning frequency is high, that is, in a case where a cleaning cycle is short, productivity of the film-forming process may deteriorate.

SUMMARY

[0004] Some embodiments of the present disclosure provide a technique capable of properly

WHAT IS CLAIMED IS:

1. A method of ~~manufacturing~~processing a ~~semiconductor device~~substrate, comprising:

performing a set a plurality of times, the set including:

(a) loading at least one substrate into a process container;

(b) performing a process of forming a nitride film on the at least one substrate by supplying a film-forming gas to the at least one substrate supported by a support in the process container;

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

(d) supplying an oxidizing gas into the process container from which the processed at least one substrate has been unloaded so as to oxidize one part of the nitride film formed inside the process container in (b) into an oxide film and maintain another part of the nitride film, which is different from the one part of the nitride film, as it is without oxidizing the another part~~.~~,

wherein in (d), a total stress of a laminated film, which includes the oxide film obtained by oxidizing the one part of the nitride film and the another part of the nitride film maintained as it is without being oxidized, is set to a tensile stress by setting a ratio of the oxide film in the laminated film to 75% or less.

2. The method of Claim 1, wherein (d) is performed each time (a), (b) and (c) are performed.

~~3. The method of Claim 1, wherein in (d), a total stress of a laminated film, which includes the oxide film obtained by oxidizing the one part of the nitride film formed inside the process container and includes the another part of the nitride film formed inside the process container and maintained as it is without being oxidized, is set to a tensile stress.~~

~~4. The method of Claim 1, wherein in (d), a ratio of the oxide film in a laminated film, which~~

~~includes the oxide film obtained by oxidizing the one part of the nitride film formed inside the process container and includes the another part of the nitride film formed inside the process container and maintained as it is without being oxidized, is set to 75% or less.~~

~~5.~~3. The method of Claim 1, wherein (d) is performed without accommodating the support in the process container.

~~6.~~4. The method of Claim ~~5~~3, wherein in (d), the nitride film formed on a surface of the support in (b) is maintained as it is without being oxidized.

~~7.~~5. The method of Claim ~~6~~4, wherein the set includes a first set and at least one subsequent set, and

wherein (b) in the at least one subsequent set is performed in a state where a substrate to be processed next is supported by the support having the nitride film formed on the surface of the support in the process container.

~~8.~~6. The method of Claim 1, wherein the at least one substrate includes a product substrate and a dummy substrate, and

(d) is performed while the support, the product substrate, and the dummy substrate are not accommodated in the process container.

~~9.~~7. The method of Claim ~~8~~6, wherein in (d), the nitride film, which is formed on a surface of each of the support, the product substrate, and the dummy substrate in (b), is maintained as it is without being oxidized.

~~10.~~8. The method of Claim ~~9~~7, wherein the set includes a first set and at least one subsequent set, and

wherein (b) in the at least one subsequent set is performed in a state where the dummy

substrate having the nitride film formed on its surface and the product substrate to be processed next are supported by the support having the nitride film formed on its surface in the process container.

~~11.~~9. The method of Claim 1, wherein the set further includes:

(e) cooling the processed at least one substrate unloaded from the interior of the process container, and

wherein (d) is performed in parallel with (e).

~~12.~~10. The method of Claim 1, wherein in (c), the processed at least one substrate is unloaded from the interior of the process container in a state where the processed at least one substrate is supported by the support,

wherein the set further includes:

(e) cooling the processed at least one substrate unloaded from the interior of the process container; and

(f) discharging the processed and cooled at least one substrate from the support, and

wherein (d) is performed in parallel with (e) and (f).

~~13.~~11. The method of Claim ~~12~~10, wherein the set further includes:

(g) charging a substrate to be processed next into the support, and

wherein (d) is performed in parallel with (e), (f), and (g).

~~14.~~12. The method of Claim 1, wherein in (d), an exhaust valve installed at an exhaust pipe configured to evacuate the interior of the process container is repeatedly opened and closed in a state where the oxidizing gas is continuously or intermittently supplied into the process container.

~~15.~~13. The method of Claim 1, wherein in (d), the interior of the process container is pulse-

evacuated in a state where the oxidizing gas is continuously or intermittently supplied into the process container.

~~16.~~14. The method of Claim 1, wherein (d) includes:

(d1) supplying the oxidizing gas into the process container in a state where the interior of the process container is evacuated; and

(d2) supplying the oxidizing gas into the process container in a state where the evacuation of the interior of the process container is stopped, and

wherein (d1) and (d2) are alternately performed a predetermined number of times.

~~17.~~15. The method of Claim 1, wherein the oxidizing gas includes an oxygen-containing gas and a hydrogen-containing gas.

~~18.~~16. The method of Claim 1, wherein the nitride film is a film at least containing nitrogen and at least one selected from the group of a semiconductor element and a metal element.

~~19.~~17. A ~~substrate processing~~ method of manufacturing a semiconductor device, comprising:

performing a set a plurality of times, the set including:

(a) loading at least one substrate into a process container;

(b) performing a process of forming a nitride film on the at least one substrate by supplying a film-forming gas to the at least one substrate supported by a support in the process container;

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

(d) supplying an oxidizing gas into the process container from which the processed at least one substrate has been unloaded so as to oxidize one part of the nitride film formed inside the process container in (b) into an oxide film and maintain another part of the nitride film, which is different from the one part of the nitride film, as it is without

oxidizing the another part~~.~~,

wherein in (d), a total stress of a laminated film, which includes the oxide film obtained by oxidizing the one part of the nitride film and the another part of the nitride film maintained as it is without being oxidized, is set to a tensile stress by setting a ratio of the oxide film in the laminated film to 75% or less.

~~20~~18. A substrate processing apparatus, comprising:

a process container in which at least one substrate is processed;

a support configured to support the at least one substrate in the process container;

a film-forming gas supply system configured to supply a film-forming gas to the at least one substrate accommodated in the process container;

an oxidizing gas supply system configured to supply an oxidizing gas into the process container;

a transport device configured to transfer the at least one substrate into and out of the process container; and

a controller configured to be capable of controlling the film-forming gas supply system, the oxidizing gas supply system, and the transport device so as to perform a set a plurality of times, the set including:

(a) loading the at least one substrate into the process container;

(b) performing a process of forming a nitride film on the at least one substrate by supplying the film-forming gas to the at least one substrate supported by the support in the process container;

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

(d) supplying the oxidizing gas into the process container from which the processed at least one substrate has been unloaded so as to oxidize one part of the nitride film formed inside the process container in (b) into an oxide film and maintain another part of the nitride film, which is different from the one part of the nitride film, as it is without

oxidizing the another part~~.~~,

wherein in (d), a total stress of a laminated film, which includes the oxide film obtained by oxidizing the one part of the nitride film and the another part of the nitride film maintained as it is without being oxidized, is set to a tensile stress by setting a ratio of the oxide film in the laminated film to 75% or less.

~~21~~19. A program that causes, by a computer, a substrate processing apparatus to perform a process comprising:

performing a set a plurality of times, the set including:

(a) loading at least one substrate into a process container of the substrate processing apparatus;

(b) performing a process of forming a nitride film on the at least one substrate by supplying a film-forming gas to the at least one substrate supported by a support in the process container;

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

(d) supplying an oxidizing gas into the process container from which the processed at least one substrate has been unloaded so as to oxidize one part of the nitride film formed inside the process container in (b) into an oxide film and maintain another part of the nitride film, which is different from the one part of the nitride film, as it is without oxidizing the another part~~.~~,

wherein in (d), a total stress of a laminated film, which includes the oxide film obtained by oxidizing the one part of the nitride film and the another part of the nitride film maintained as it is without being oxidized, is set to a tensile stress by setting a ratio of the oxide film in the laminated film to 75% or less.

20. The method of Claim 1, wherein in (d), a thickness of the one part of the nitride film subjected to oxidization is set to 65% or less of a thickness of the nitride film before the oxidization.

21. The method of Claim 1, wherein in (d), a thickness of the one part of the nitride film subjected to oxidization is smaller than a thickness of the another part of the nitride film maintained as it is without being oxidized.