SUBSTRATE PROCESSING APPARATUS, METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE, AND ~~PROGRAM~~RECORDING MEDIUM

TECHNICAL FIELD

[0001] The present disclosure relates to a substrate processing apparatus, a method of manufacturing a semiconductor device, and a ~~program~~recording medium.

BACKGROUND

[0002] As a process of manufacturing a semiconductor device, a process of supplying a process gas to a substrate (wafer) in a process chamber and forming a film on the substrate is performed. Along with the high miniaturization and increased layering of a semiconductor device, when the wafer in the process chamber is a pattern wafer, the in-plane film thickness uniformity of the film formed on the wafer may sometimes deteriorate because the supply amount of the process gas is insufficient near the center of the wafer. In view of this, the process gas is sometimes supplied to the center of the wafer to improve the in-plane film thickness uniformity on the wafer.

[Prior Art Documents]

[0003] Patent Documents

Patent Document 1: International Patent Application Publication No. 2018/154823

Patent Document 2: International Patent Application Publication No. 2016/157401

SUMMARY

[0004] The present disclosure provides some embodiments of a configuration capable of improving an in-plane film thickness uniformity of a film formed on a substrate.

[0005] According to one embodiment of the present disclosure, there is provided a technique that includes: a ~~process gas~~first nozzle configured to supply a process gas to a process chamber that processes a substrate; a~~n inert gas~~second nozzle arranged to be spaced apart by a predetermined distance from the ~~process gas~~first nozzle in a circumferential direction of the substrate and

configured to supply an inert gas to the process chamber; and a reaction ~~tube~~container defining the process chamber therein and including a first protrusion protruding outward to accommodate the ~~process gas~~first nozzle and a second protrusion protruding outward to accommodate the ~~inert gas~~second nozzle, wherein the inert gas supplied from the ~~inert gas~~second nozzle is supplied toward the ~~process gas~~ first nozzle to cause the flow direction of the process gas to be oriented toward the substrate.

BRIEF DESCRIPTION OF DRAWINGS

[0006] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the present disclosure.

[0007] FIG. 1 is a schematic configuration diagram of a substrate processing apparatus preferably used in one embodiment of the present disclosure, in which a process furnace is shown in a vertical sectional view.

FIG. 2 is a sectional view taken along line A-A in FIG. 1, showing a part of the process furnace of the substrate processing apparatus preferably used in one embodiment of the present disclosure.

FIG. 3 is a schematic configuration diagram of a controller of the substrate processing apparatus preferably used in one embodiment of the present disclosure, in which a control system of the controller is shown in a block diagram.

FIG. 4 is a diagram showing a film-forming sequence of the substrate processing apparatus preferably used in one embodiment of the present disclosure.

FIG. 5A is a diagram showing a concentration distribution of precursor radicals in the process furnace of the substrate processing apparatus preferably used in one embodiment of the present disclosure, and FIG. 5B is a diagram for explaining the flow of a gas near a counter nozzle in FIG. 5A.

FIG. 6 is a diagram showing the analysis results of an in-plane film thickness distributions for the films formed on the substrates by using the substrate processing apparatus according to one embodiment of the present disclosure (Present Example), a substrate processing apparatus

WHAT IS CLAIMED IS:

1. A substrate processing apparatus, comprising:

a ~~process gas~~ first nozzle configured to supply a process gas to a process chamber that processes a substrate;

a~~n~~ ~~inert gas~~ second nozzle arranged to be spaced apart by a predetermined distance from the ~~process gas~~ first nozzle in a circumferential direction of the substrate and configured to supply an inert gas to the process chamber; and

a reaction ~~tube~~ container defining the process chamber therein and including a first protrusion protruding outward to accommodate the ~~process gas~~ first nozzle and a second protrusion protruding outward to accommodate the ~~inert gas~~ second nozzle,

wherein the inert gas supplied from the ~~inert gas~~ second nozzle is supplied toward the ~~process gas~~ first nozzle to cause a flow direction of the process gas to be oriented toward the substrate.

2. The substrate processing apparatus of Claim 1, wherein the inert gas supplied from the ~~inert gas~~ second nozzle is supplied toward the ~~process gas~~ first nozzle to form a vortex flow of the inert gas in a vicinity of the second protrusion.

3. The substrate processing apparatus of Claim 2, wherein the process gas supplied from the ~~process gas~~ first nozzle and flowing between an end portion of the substrate and an inner wall of the reaction ~~tube~~ container flows toward a center of the substrate by the vortex flow of the inert gas.

4. The substrate processing apparatus of Claim 2, further comprising:

an exhauster configured to exhaust an atmosphere in the process chamber,

wherein the inert gas supplied from the ~~inert gas~~ second nozzle is caused to flow toward the exhauster between an end portion of the substrate and an inner wall of the reaction ~~tube~~ container by the vortex flow of the inert gas near the second protrusion.

5. The substrate processing apparatus of Claim 2, wherein the vortex flow of the inert gas is formed to overlap with a part of a peripheral edge portion of the substrate.

6. The substrate processing apparatus of Claim 5, wherein a concentration of the process gas is reduced at the part of the peripheral edge portion of the substrate at which the vortex flow of the inert gas is formed.

7. The substrate processing apparatus of any one of Claims 1 to 6, wherein the reaction container further comprises a third protrusion protruding outward to accommodate an inert gas nozzle ~~two inert gas nozzles are arranged~~.

8. The substrate processing apparatus of Claim 7, further comprising:

an exhauster configured to exhaust an atmosphere in the process chamber,

wherein the second nozzle accommodated by the second protrusion and the inert gas nozzle accommodated by the third protrusion ~~two inert gas nozzles~~ are arranged line-symmetrically to a straight line connecting the ~~process gas~~ first nozzle and the exhauster.

9. The substrate processing apparatus of Claim 2, wherein the vortex flow of the inert gas and the process gas repel each other without being mixed, and the flow direction of the process gas is changed to a flow direction of the vortex flow of the inert gas.

10. The substrate processing apparatus of Claim 1, wherein the ~~inert gas~~ second nozzle is arranged at a position of 15 degrees or more and 120 degrees or less from a straight line connecting a center of the ~~process gas~~ first nozzle and a center of the substrate in the circumferential direction of the substrate.

11. The substrate processing apparatus of Claim 1, wherein a flow rate of the inert gas supplied from the ~~inert gas~~ second nozzle is 1/4 or more and 2/3 or less of a total flow rate of the process gas supplied from the ~~process gas~~ first nozzle.

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

loading a substrate into a process chamber that processes the substrate; and

processing the substrate by supplying a process gas from a ~~process gas~~ first nozzle to the process chamber,

wherein in the act of processing the substrate, an inert gas is supplied from a~~n inert gas~~ second nozzle to the process chamber toward the ~~process gas~~ first nozzle to cause a flow direction of the process gas to be oriented toward the substrate.

13. A non-transitory computer-readable recording medium storing a program that causes, by a computer, a substrate processing apparatus to perform a process comprising:

loading a substrate into a process chamber of the substrate processing apparatus;

processing the substrate by supplying a process gas from a ~~process gas~~ first nozzle to the process chamber,

wherein in the act of processing the substrate, ~~supplying~~ an inert gas is supplied from a~~n inert gas~~ second nozzle to the process chamber toward the ~~process gas~~ first nozzle to cause a flow direction of the process gas to be oriented toward the substrate.