

[CLAIMS]

[Claim 1]

A method of manufacturing a semiconductor device, comprising:

5 (a) forming a first oxide layer by supplying an oxygen-containing gas and a hydrogen-containing gas to a heated substrate at a first pressure less than an atmospheric pressure and by oxidizing a surface of the substrate; and

(b) forming a second oxide layer by supplying the oxygen-containing gas and the hydrogen-containing gas to the heated substrate at a second pressure less than the atmospheric pressure and different from the first pressure and by oxidizing the surface
10 of the substrate on which the first oxide layer is formed,

wherein the first pressure is lower than the second pressure, and

the first pressure is set in (a) such that an oxidation rate of oxidizing the surface of the substrate at a center of the substrate is greater than that of oxidizing the surface of
15 the substrate in vicinity of an outer periphery of the substrate.

[Claim 2]

The method of claim 1, wherein the oxygen-containing gas and the hydrogen-containing gas are supplied from the outer periphery of the substrate toward the center
20 of the substrate in (a) and (b).

[Claim 3]

The method of claim 2, wherein the surface of the substrate is oxidized in (a) and (b) while rotating the substrate.

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[Claim 4]

The method of claim 3, wherein the second pressure is set in (b) such that an oxidation rate of oxidizing the surface of the substrate on which the first oxide layer is formed at the center of the substrate is less than that of oxidizing the surface of the substrate on which the first oxide layer is formed in the vicinity of the outer periphery of the substrate.

[Claim 5]

A method of manufacturing a semiconductor device, comprising:

10 (a) forming a first oxide layer by supplying an oxygen-containing gas and a hydrogen-containing gas to a heated substrate at a first pressure less than an atmospheric pressure and by oxidizing a surface of the substrate; and

(b) forming a second oxide layer by supplying the oxygen-containing gas and the hydrogen-containing gas to the heated substrate at a second pressure less than the atmospheric pressure and different from the first pressure and by oxidizing the surface of the substrate on which the first oxide layer is formed,

wherein the first pressure is higher than the second pressure, and

the first pressure is set in (a) such that an oxidation rate of oxidizing the surface of the substrate at a center of the substrate is less than that of oxidizing the surface of the substrate in vicinity of an outer periphery of the substrate.

[Claim 6]

The method of claim 5, wherein the second pressure is set in (b) such that an oxidation rate of oxidizing the surface of the substrate on which the first oxide layer is formed at the center of the substrate is greater than that of oxidizing the surface of the substrate on which the first oxide layer is formed in the vicinity of the outer periphery of the substrate.

[Claim 7]

The method of claim 1, further comprising

(c) forming an initial oxide layer by supplying a second oxygen-containing gas
5 to the substrate and by oxidizing the surface of the substrate before (a).

[Claim 8]

The method of claim 7, wherein a rate of forming the initial oxide layer in (c) is
less than a rate of forming the first oxide layer in (a).

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[Claim 9]

The method of claim 7, wherein the second oxygen-containing gas supplied in (c)
comprises oxygen gas free of hydrogen.

15 [Claim 10]

The method of claim 1, further comprising

(d) supplying an inert gas to the substrate through an inert gas nozzle different
from one or more gas nozzles through which the oxygen-containing gas and the
hydrogen-containing gas are supplied to the substrate.

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[Claim 11]

The method of claim 10, wherein the inert gas is supplied to the substrate in (d)
through a plurality of inert gas nozzles comprising the inert gas nozzle.

25 [Claim 12]

The method of claim 1, further comprising

(e) supplying hydrogen gas to the substrate through a hydrogen gas nozzle different from one or more gas nozzles through which the oxygen-containing gas and the hydrogen-containing gas are supplied to the substrate.

5 [Claim 13]

The method of claim 12, wherein the hydrogen gas is supplied to the substrate in (e) through a plurality of hydrogen gas nozzles comprising the hydrogen gas nozzle.

[Claim 14]

10 The method of claim 1, further comprising
(f) supplying an inert gas to the substrate in (a) and (b),
wherein a supply flow rate of the inert gas to the substrate in (a) is different from that of the inert gas to the substrate in (b).

15 [Claim 15]

The method of claim 1, further comprising
(g) supplying hydrogen gas to the substrate in (a) and (b),
wherein a supply flow rate of the hydrogen gas to the substrate in (a) is different from that of the hydrogen gas to the substrate in (b).

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[Claim 16]

A substrate processing apparatus comprising:
a process vessel in which a substrate is accommodated;
an oxygen-containing gas supplier configured to supply an oxygen-containing
25 gas into the process vessel;
a hydrogen-containing gas supplier configured to supply a hydrogen-containing gas into the process vessel;

a heater configured to heat the substrate accommodated in the process vessel;
an exhauster configured to exhaust an inner atmosphere of the process vessel;
and

a controller capable of controlling the oxygen-containing gas supplier, the
5 hydrogen-containing gas supplier, the heater and the exhauster to perform:

(a) forming a first oxide layer by supplying the oxygen-containing gas
and the hydrogen-containing gas to the heated substrate at a first pressure less than an
atmospheric pressure and by oxidizing a surface of the substrate; and

(b) forming a second oxide layer by supplying the oxygen-containing gas
10 and the hydrogen-containing gas to the heated substrate at a second pressure less than
the atmospheric pressure and different from the first pressure and by oxidizing the
surface of the substrate on which the first oxide layer is formed,

wherein the first pressure is lower than the second pressure, and

the first pressure is set in (a) such that an oxidation rate of oxidizing the surface
15 of the substrate at a center of the substrate is greater than that of oxidizing the surface of
the substrate in vicinity of an outer periphery of the substrate.

[Claim 17]

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

(a) forming a first oxide layer by supplying an oxygen-containing gas and a
hydrogen-containing gas to a heated substrate accommodated in a process vessel of the
substrate processing apparatus at a first pressure less than an atmospheric pressure and
by oxidizing a surface of the substrate; and

25 (b) forming a second oxide layer by supplying the oxygen-containing gas and
the hydrogen-containing gas to the heated substrate at a second pressure less than the

atmospheric pressure and different from the first pressure and by oxidizing the surface of the substrate on which the first oxide layer is formed,

wherein the first pressure is lower than the second pressure, and

the first pressure is set in (a) such that an oxidation rate of oxidizing the surface of the substrate at a center of the substrate is greater than that of oxidizing the surface of the substrate in vicinity of an outer periphery of the substrate.

[Claim 18]

A substrate processing apparatus comprising:

10 a process vessel in which a substrate is accommodated;

an oxygen-containing gas supplier configured to supply an oxygen-containing gas into the process vessel;

a hydrogen-containing gas supplier configured to supply a hydrogen-containing gas into the process vessel;

15 a heater configured to heat the substrate accommodated in the process vessel;

an exhauster configured to exhaust an inner atmosphere of the process vessel;

and

a controller capable of controlling the oxygen-containing gas supplier, the hydrogen-containing gas supplier, the heater and the exhauster to perform:

20 (a) forming a first oxide layer by supplying the oxygen-containing gas and the hydrogen-containing gas to the heated substrate at a first pressure less than an atmospheric pressure and by oxidizing a surface of the substrate; and

(b) forming a second oxide layer by supplying the oxygen-containing gas and the hydrogen-containing gas to the heated substrate at a second pressure less than the atmospheric pressure and different from the first pressure and by oxidizing the surface of the substrate on which the first oxide layer is formed,

wherein the first pressure is higher than the second pressure, and

the first pressure is set in (a) such that an oxidation rate of oxidizing the surface of the substrate at a center of the substrate is less than that of oxidizing the surface of the substrate in vicinity of an outer periphery of the substrate.

5 [Claim 19]

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

(a) forming a first oxide layer by supplying an oxygen-containing gas and a hydrogen-containing gas to a heated substrate accommodated in a process vessel of the substrate processing apparatus at a first pressure less than an atmospheric pressure and
10 by oxidizing a surface of the substrate; and

(b) forming a second oxide layer by supplying the oxygen-containing gas and the hydrogen-containing gas to the heated substrate at a second pressure less than the atmospheric pressure and different from the first pressure and by oxidizing the surface
15 of the substrate on which the first oxide layer is formed,

wherein the first pressure is higher than the second pressure, and

the first pressure is set in (a) such that an oxidation rate of oxidizing the surface of the substrate at a center of the substrate is less than that of oxidizing the surface of the substrate in vicinity of an outer periphery of the substrate.

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[Claim 20]

A method of processing a substrate, comprising:

(a) forming a first oxide layer by supplying an oxygen-containing gas and a hydrogen-containing gas to a heated substrate at a first pressure less than an
25 atmospheric pressure and by oxidizing a surface of the substrate; and

(b) forming a second oxide layer by supplying the oxygen-containing gas and the hydrogen-containing gas to the heated substrate at a second pressure less than the

atmospheric pressure and different from the first pressure and by oxidizing the surface of the substrate on which the first oxide layer is formed,

wherein the first pressure is lower than the second pressure, and

the first pressure is set in (a) such that an oxidation rate of oxidizing the surface
5 of the substrate at a center of the substrate is greater than that of oxidizing the surface of the substrate in vicinity of an outer periphery of the substrate.

[Claim 21]

A method of processing a substrate, comprising:

10 (a) forming a first oxide layer by supplying an oxygen-containing gas and a hydrogen-containing gas to a heated substrate at a first pressure less than an atmospheric pressure and by oxidizing a surface of the substrate; and

(b) forming a second oxide layer by supplying the oxygen-containing gas and the hydrogen-containing gas to the heated substrate at a second pressure less than the
15 atmospheric pressure and different from the first pressure and by oxidizing the surface of the substrate on which the first oxide layer is formed,

wherein the first pressure is higher than the second pressure, and

the first pressure is set in (a) such that an oxidation rate of oxidizing the surface of the substrate at a center of the substrate is less than that of oxidizing the surface of
20 the substrate in vicinity of an outer periphery of the substrate.