

[CLAIMS]

[Claim 1]

A substrate processing apparatus comprising:

5 a substrate retainer comprising:

a product wafer support region where a plurality of product wafers with a pattern formed thereon are arranged and supported;

an upper dummy wafer support region provided above the product wafer support region and capable of supporting a plurality of dummy wafers; and

10 a lower dummy wafer support region provided below the product wafer support region and capable of supporting a plurality of dummy wafers;

a process chamber in which the substrate retainer is accommodated;

a first gas supplier, a second gas supplier and a third gas supplier extending in a vertical direction along the substrate retainer and configured to supply gases into the process chamber; and

15 an exhaust system configured to exhaust an inner atmosphere of the process chamber,

wherein the first gas supplier comprises a plurality of first supply holes and is configured to supply a purge gas or an inert gas,

20 wherein the second gas supplier interposed between the first gas supplier and the third gas supplier comprises a gas supply port and is configured to supply a thermally decomposable source gas, the gas supply port being constituted by a plurality of second supply holes or by a slit-shaped opening provided in an entire range of the product wafer support region without being provided in the upper dummy wafer support region and the lower dummy wafer support region,

25 wherein the third gas supplier comprises a plurality of third supply holes and is configured to supply the purge gas or the inert gas,

wherein at least one of (i) the plurality of first supply holes and (ii) the plurality of third supply holes includes holes located corresponding to all the plurality of product wafers and all the plurality of dummy wafers in the upper dummy wafer support region and the lower dummy wafer support region,

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wherein an upper end of an uppermost supply hole among at least one of (i) the plurality of first supply holes and (ii) the plurality of third supply holes is arranged corresponding to an uppermost dummy wafer among the plurality of dummy wafers supported in the upper dummy wafer support region and a lower end of a lowermost supply hole among the plurality of first supply holes and the plurality of third supply holes is arranged corresponding to a lowermost dummy wafer among the plurality of dummy wafers supported in the lower dummy wafer support region,

~~wherein each of opening areas of holes located corresponding to all the plurality of dummy wafers is greater than each of opening areas of holes among the first supply holes and the third supply holes provided in the product wafer support region, and~~

wherein the gas supply port of the second gas supplier is provided such that an upper end of the gas supply port is arranged lower than a lowermost dummy wafer among the plurality of dummy wafers supported in the upper dummy wafer support region, and a lower end of the gas supply port is arranged higher than an uppermost dummy wafer among the plurality of dummy wafers supported in the lower dummy wafer support region.

[Claim 2]

The substrate processing apparatus of claim 1, wherein the first gas supplier, the second gas supplier and the third gas supplier are arranged in vicinity of an outer periphery of the process chamber sequentially in an order of the first gas supplier, the second gas supplier and the third gas supplier, and are connected to a first gas supply system, a second gas supply system and a third supply system provided outside the process chamber in vicinity of a lower end of the process chamber so as to enable a fluid to flow from the first gas supply system, the second gas supply system and the third gas supply system to the first gas supplier, the second gas supplier and the third gas supplier, respectively,

wherein the first gas supply system and the third gas supply system are configured to supply the purge gas or the inert gas, and the second gas supply system is configured to supply the thermally decomposable source gas, and

wherein both of the plurality of first supply holes and the plurality of third supply holes include holes located corresponding to all the plurality of dummy wafers;
~~wherein each of the holes located corresponding to all the plurality of dummy wafers has an opening area greater than each of the opening areas of the first supply holes and~~
5 ~~the third supply holes provided in the product wafer support region.~~

[Claim 3]

The substrate processing apparatus of claim 1, wherein at least one among the first gas supplier and the third gas supplier comprises:

10 an ascending pipe connected to the first gas supply system or the third gas supply system so as to enable a fluid to flow from the first gas supply system or the third gas supply system to a lower end of the ascending pipe; and

a descending pipe connected to an upper end of the ascending pipe so as to enable the fluid to flow and provided substantially parallel to the ascending pipe,

15 wherein the plurality of first supply holes and the plurality of third supply holes are provided at least at the descending pipe.

[Claim 4]

The substrate processing apparatus of claim 1, wherein at least one among the first gas supplier and the third gas supplier is configured such that a substantial opening area obtained from opening areas of the plurality of first supply holes and the plurality of third supply holes arranged in all the upper dummy wafer support region and all the lower dummy wafer support region by averaging along a longitudinal direction is greater than a substantial opening area obtained from opening areas of the plurality of first supply holes and the plurality of third supply holes arranged in all the product wafer support region by averaging along the longitudinal direction.

[Claim 5]

The substrate processing apparatus of claim 3, wherein at least one among the first gas supplier and the third gas supplier is configured such that the plurality of first supply holes and the plurality of third supply holes are provided at both of the ascending

pipe and the descending pipe in the upper dummy wafer support region and the lower dummy wafer support region and the plurality of first supply holes and the plurality of third supply holes are provided at the descending pipe in the product wafer support region without being provided at the ascending pipe.

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[Claim 6]

The substrate processing apparatus of claim 2, wherein the second gas supplier is configured to supply the source gas through the second gas supply system while the purge gas or the inert gas is supplied through at least one among the first gas supplier
10 and the third gas supplier, and

wherein at least one among the first gas supplier and the third gas supplier is further configured to supply a reactive gas, which is more difficult to be thermally decomposed or activated than the source gas, into the process chamber when the source gas is not supplied through the second gas supplier.

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[Claim 7]

The substrate processing apparatus of claim 1, wherein the plurality of first supply holes of the first gas supplier and the plurality of third supply holes of the third gas supplier are provided in a manner corresponding to the plurality of product wafers
20 in the product wafer support region and the plurality of dummy wafers in the upper dummy wafer support region and the lower dummy wafer support region, respectively.

[Claim 8]

The substrate processing apparatus of claim 1, wherein the plurality of first supply holes of the first gas supplier and the plurality of third supply holes of the third gas supplier comprise a plurality of vertically elongated slits facing the entirety of the plurality of product wafers or the plurality of dummy wafers.

[Claim 9]

30 A substrate processing apparatus comprising:
a substrate retainer comprising:

a product wafer support region where a plurality of product wafers with a pattern formed thereon are arranged and supported;

an upper dummy wafer support region provided above the product wafer support region and capable of supporting a plurality of dummy wafers; and

5 a lower dummy wafer support region provided below the product wafer support region and capable of supporting a plurality of dummy wafers;

a process chamber in which the substrate retainer is accommodated;

a first gas supplier, a second gas supplier and a third gas supplier extending in a vertical direction along the substrate retainer and configured to supply gases into the
10 process chamber; and

an exhaust system configured to exhaust an inner atmosphere of the process chamber,

wherein the first gas supplier comprises a plurality of first supply holes and is configured to supply a purge gas or an inert gas,

15 wherein the second gas supplier interposed between the first gas supplier and the third gas supplier comprises a gas supply port and is configured to supply a thermally decomposable source gas, the gas supply port being constituted by a plurality of second supply holes or by a slit-shaped opening provided in an entire range of the product wafer support region without being provided in the upper dummy wafer support region
20 and the lower dummy wafer support region,

wherein the third gas supplier comprises a plurality of third supply holes and is configured to supply the purge gas or the inert gas,

wherein at least one of (i) the plurality of first supply holes and (ii) the plurality of third supply holes includes holes located corresponding to all the plurality of product
25 wafers and all the plurality of dummy wafers in the upper dummy wafer support region and the lower dummy wafer support region,

wherein an upper end of an uppermost supply hole among at least one of (i) the plurality of first supply holes and (ii) the plurality of third supply holes is arranged corresponding to an uppermost dummy wafer among the plurality of dummy wafers
30 supported in the upper dummy wafer support region and a lower end of a lowermost supply hole among at least one of (i) the plurality of first supply holes and (ii) the

plurality of third supply holes is arranged corresponding to a lowermost dummy wafer among the plurality of dummy wafers supported in the lower dummy wafer support region,

~~wherein each of opening areas of holes of at least one of (i) the first supply holes and (ii) the third supply holes provided in the upper dummy wafer support region and the lower dummy wafer support region is greater than each of opening areas of the first supply holes and the third supply holes provided in the product wafer support region,~~
and

wherein the first gas supplier or the third gas supplier is configured such that an opening width of the plurality of first supply holes and the plurality of third supply holes averaged out along a longitudinal direction is 1% or less of a square root of a cross-sectional area of a flow path of the first gas supplier or the third gas supplier, and the second gas supplier is configured such that an opening width of the gas supply port is 3% or more of a square root of a cross-sectional area of a flow path of the second gas supplier.

[Claim 10]

The substrate processing apparatus of claim 9, wherein the process chamber is constituted by a cylinder whose inner diameter is 104 % to 108 % of a maximum diameter of the plurality of product wafers accommodatable in the process chamber, and the flow paths of the first gas supplier, the second gas supplier and the third gas supplier are provided in a supply area formed by a part of the process chamber protruding outward while separated from one another.

[Claim 11]

The substrate processing apparatus of claim 10, further comprising a partition wall serving as a part of a sidewall of the cylinder and constituting a boundary between the supply area and the process chamber,

wherein three circumferentially elongated gas supply slits configured to supply gases into the cylinder are arranged in the partition wall along a circumferential direction and in a manner corresponding to the flow paths of the first gas supplier, the

second gas supplier and the third gas supplier, respectively, and the three gas supply slits are provided in a grid pattern such that a plurality of openings serving as the three gas supply slits are arranged along a height direction and in a manner corresponding to the plurality of product wafers and the plurality of dummy wafers, and the number of
5 the openings is the same as a total number of the product wafers and the dummy wafers.

[Claim 12]

The substrate processing apparatus of claim 11, wherein the plurality of first supply holes of the first gas supplier and the plurality of third supply holes of the third
10 gas supplier are provided to face the gas supply slits corresponding to the plurality of first supply holes of the first gas supplier and the plurality of third supply holes of the third gas supplier, respectively.

[Claim 13]

15 A method of manufacturing a semiconductor device comprising:

(a) accommodating a plurality of product wafers with a pattern formed thereon in a product wafer support region of a substrate retainer and a plurality of dummy wafers in an upper dummy wafer support region and a lower dummy wafer support region of the substrate retainer, wherein the substrate retainer comprises:

20 the product wafer support region where the plurality of product wafers are arranged and supported;

the upper dummy wafer support region provided above the product wafer support region and capable of supporting the plurality of dummy wafers; and

25 the lower dummy wafer support region provided below the product wafer support region and capable of supporting the plurality of dummy wafers;

(b) loading the substrate retainer in which the plurality of product wafers and the plurality of dummy wafers are accommodated into a process chamber configured to accommodate the substrate retainer;

(c) supplying a purge gas or an inert gas to the substrate retainer through at least
30 one among a first gas supplier and a third gas supplier, wherein the first gas supplier and the third gas supplier extend in a vertical direction along the substrate retainer, a

plurality of gas supply holes are provided at each of the first gas supplier and the third gas supplier, the plurality of gas supply holes includes [WHL1]holes located corresponding to all the plurality of product wafers and all the plurality of dummy wafers in the upper dummy wafer support region and the lower dummy wafer support region, an upper end of an uppermost gas supply hole among the plurality of gas supply holes is arranged corresponding to an uppermost dummy wafer among the plurality of dummy wafers supported in the upper dummy wafer support region, and a lower end of a lowermost gas supply hole among the plurality of gas supply holes is arranged corresponding to a lowermost dummy wafer among the plurality of dummy wafers supported in the lower dummy wafer support region, and each of opening areas of holes located corresponding to all the plurality of dummy wafers among the first supply holes and the third supply holes is greater than each of opening areas of the first supply holes and the third supply holes provided in the product wafer support region; and

(d) processing the plurality of product wafers by supplying a source gas to the substrate retainer through a second gas supplier, wherein the second gas supplier extends in the vertical direction between the first gas supplier and the third gas supplier along the substrate retainer and comprises a gas supply port constituted by a plurality of gas supply holes or by a slit-shaped opening, an upper end of the gas supply port is arranged lower than a lowermost dummy wafer among the plurality of dummy wafers supported in the upper dummy wafer support region, and a lower end of the gas supply port is arranged higher than an uppermost dummy wafer among the plurality of dummy wafers supported in the lower dummy wafer support region.

[Claim 14] A program related to a substrate processing apparatus, wherein the program causes, by a computer, the substrate processing apparatus to perform:

(a) accommodating a plurality of product wafers with a pattern formed thereon in a product wafer support region of a substrate retainer and a plurality of dummy wafers in an upper dummy wafer support region and a lower dummy wafer support region of the substrate retainer, wherein the substrate retainer comprises:

the product wafer support region where the plurality of product wafers are arranged and supported;

the upper dummy wafer support region provided above the product wafer support region and capable of supporting the plurality of dummy wafers; and

the lower dummy wafer support region provided below the product wafer support region and capable of supporting the plurality of dummy wafers;

5 (b) loading the substrate retainer in which the plurality of product wafers and the plurality of dummy wafers are accommodated into a process chamber configured to accommodate the substrate retainer;

(c) supplying a purge gas or an inert gas to the substrate retainer through at least one among a first gas supplier and a third gas supplier, wherein the first gas supplier and
10 the third gas supplier extend in a vertical direction along the substrate retainer, a plurality of gas supply holes are provided at each of the first gas supplier and the third gas supplier, the plurality of gas supply holes include holes located corresponding to all the plurality of product wafers and all the plurality of dummy wafers in the upper dummy wafer support region and the lower dummy wafer support region, an upper end
15 of an uppermost gas supply hole among the plurality of gas supply holes is arranged corresponding to an uppermost dummy wafer among the plurality of dummy wafers supported in the upper dummy wafer support region, and a lower end of a lowermost gas supply hole among the plurality of gas supply holes is arranged corresponding to a lowermost dummy wafer among the plurality of dummy wafers supported in the lower
20 dummy wafer support region, ~~and each of opening areas of holes located corresponding to all the plurality of dummy wafers among the first supply holes and the third supply holes is greater than each of opening areas of the first supply holes and the third supply holes provided in the product wafer support region; and~~

(d) processing the plurality of product wafers by supplying a source gas to the
25 substrate retainer through a second gas supplier, wherein the second gas supplier extends in the vertical direction between the first gas supplier and the third gas supplier along the substrate retainer and comprises a gas supply port constituted by a plurality of gas supply holes or by a slit-shaped opening, an upper end of the gas supply port is arranged lower than a lowermost dummy wafer among the plurality of dummy wafers
30 supported in the upper dummy wafer support region, and a lower end of the gas supply

port is arranged higher than an uppermost dummy wafer among the plurality of dummy wafers supported in the lower dummy wafer support region.

[Claim 15]

5 The method of manufacturing a semiconductor device of claim 13, wherein (c) and (d) are performed simultaneously, and

 wherein a flow rate of the inert gas supplied by each of the first gas supplier and the third gas supplier is set within 0.1 slm to 5 slm.

10 [Claim 16]

 The method of manufacturing a semiconductor device of claim 15, further comprising:

 (e) supplying a reactive gas to the substrate retainer through at least one among a first gas supplier and a third gas supplier and supplying the inert gas to the substrate
15 retainer through at least one among a first gas supplier and a third gas supplier, wherein a flow rate of the inert gas supplied by the first gas supplier or the third gas supplier is set within 0 slm to 2 slm that is lower than the flow rate during the (d).