

[CLAIMS]

[Claim 1]

A substrate processing apparatus comprising:

5 a controller configured to be capable of controlling an execution of a predetermined process on a substrate by executing a process recipe constituted by a plurality of steps; and

a sign detector configured to: ~~acquire sensor data related to a component subject to an abnormal sign detection, to~~

10 create a normal model by acquiring a first set of sensor data related to a component subject to an abnormal sign detection;

acquire a second set of sensor data whose data amount is smaller than that of the first set of sensor data;

15 determine whether to use the normal model by statistically determining whether or not a distribution of the second set of sensor data is equal to that of the normal model;
and, and to monitor an apparatus state based on the normal model;

~~wherein the sign detector is further configured to:~~

20 ~~acquire the sensor data after a replacement or a maintenance of the component subject to the abnormal sign detection, and acquire vibration data detected by a vibration sensor among the sensor data in a designated step of the plurality of steps constituting the process recipe;~~

~~convert the acquired vibration data into a vibration frequency spectrum;~~

~~extract the converted vibration frequency spectrum at predetermined frequency~~

intervals;

~~calculate an average value and a standard deviation of an amplitude of the vibration frequency spectrum for each extracted frequency by using data of the process recipe executed a predetermined number of times under a normal state;~~

5 ~~re create the normal model by using the acquired average value and the acquired standard deviation of the amplitude of the vibration frequency spectrum; and~~

detect an abnormal sign before an abnormal apparatus stop occurs by monitoring ~~the an~~ apparatus state based on the normal model if it is determined that the normal model is to be used.

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[Claim 2]

The substrate processing apparatus of claim 1, wherein the sign detector is further configured to: ~~determine, based on the sensor data whose data amount is smaller than an amount of data required to create the normal model, whether or not the normal model before the replacement or the maintenance is appropriate to be used as the normal model after the replacement or the maintenance~~

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acquire vibration data detected by a vibration sensor among the first set of sensor data in a designated step of the plurality of steps constituting the process recipe;

convert the acquired vibration data into a vibration frequency spectrum;

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extract the converted vibration frequency spectrum at predetermined frequency intervals;

calculate an average value and a standard deviation of an amplitude of the

vibration frequency spectrum for each extracted frequency by using data of the process
recipe executed a predetermined number of times under a normal state; and
re-create the normal model by using the acquired average value and the
acquired standard deviation of the amplitude of the vibration frequency spectrum.

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[Claim 3]

The substrate processing apparatus of claim 2, wherein the sign detector is further configured to:

use the normal model before ~~the a~~ replacement or ~~the a~~ maintenance as the
10 normal model after the replacement or the maintenance when it is determined that the
normal model before the replacement or the maintenance is appropriate to be used as the
normal model after the replacement or the maintenance; and

acquire the first set of sensor data and create the normal model after the
replacement or the maintenance based on the acquired first set of sensor data when it is
15 determined that the normal model before the replacement or the maintenance is not
appropriate to be used as the normal model after the replacement or the maintenance.

[Claim 4]

The substrate processing apparatus of claim 1, wherein the designated step
20 comprises decreasing an inner pressure of a process chamber in which the substrate is
processed from an atmospheric pressure to a predetermined pressure.

[Claim 5]

The substrate processing apparatus of claim 12, wherein the sign detector is further configured to:

create the normal model by using the average value and the standard deviation of the amplitude of the vibration frequency spectrum;

5 compare an amplitude value of the normal model with a predetermined threshold value for the extracted frequency; and

determine that the abnormal sign is present when the number of amplitude values of frequencies deviating from the predetermined threshold value is equal to or greater than a predetermined number.

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[Claim 6]

The substrate processing apparatus of claim 5, wherein the predetermined threshold value is calculated, by using the average value and the standard deviation, to fall within a range from a lower limit obtained by subtracting three times of the standard deviation from the average value to an upper limit obtained by adding three times of the standard deviation to the average value.

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[Claim 7]

The substrate processing apparatus of claim 5, wherein the sign detector is further configured to:

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generate an alarm when it is determined that the abnormal sign is present, and

display, on a screen, predetermined the sensor data of the component in which the abnormality sign is recognized.

[Claim 8]

The substrate processing apparatus of claim 1, wherein the component subject to the abnormal sign detection comprises an exhauster configured to exhaust an inner atmosphere of a process chamber in which the substrate is processed, and

the ~~sign detector is further configured to create the normal model by acquiring~~
first set of sensor data comprises at least one ~~sensor data~~ selected from the group consisting of the vibration data detected by the vibration sensor, electric current data of the exhauster, temperature data of the exhauster and exhaust pressure data of the exhauster.

[Claim 9]

A method of manufacturing a semiconductor device, comprising
processing a substrate by performing a predetermined process on the substrate
by executing a process recipe constituted by a plurality of steps,
wherein the processing the substrate comprises:

(a) acquiring a first set of sensor data related to a component subject to an abnormal sign detection ~~after a replacement or a maintenance of a component;~~

(b) acquiring a second set of sensor data whose data amount is smaller than that of the first set of sensor data;

(c) determining whether to use the normal model by statistically determining whether or not a distribution of the second set of sensor data is equal to that of the

normal model; and

~~—— (b) acquiring vibration data detected by a vibration sensor among the sensor data in a designated step of the plurality of steps constituting the process recipe;~~

~~—— (c) converting the acquired vibration data into a vibration frequency spectrum;~~

5 ~~—— (d) extracting frequencies in a predetermined range of the converted vibration frequency spectrum at predetermined frequency intervals, and calculating an average value and a standard deviation of an amplitude of the vibration frequency spectrum for each extracted frequency by using data of the process recipe executed a predetermined number of times under a normal state;~~

10 ~~—— (e) re-creating a normal model by using the average value and the standard deviation of the amplitude of the vibration frequency spectrum; and~~

~~(f)~~ detecting an abnormal sign before an abnormal apparatus stop occurs by monitoring an apparatus state based on the normal model if it is determined that the normal model is to be used.

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[Claim 10]

A sign detection program executed by a substrate processing apparatus configured ~~to acquire sensor data related to a component subject to an abnormal sign detection,~~ to create a normal model and to monitor an apparatus state based on the
20 normal model, wherein the sign detection program causes, by a computer, the substrate processing apparatus to perform:

(a) acquiring ~~the~~ a first set of sensor data related to a ~~after a replacement or a maintenance of the~~ component subject to ~~the~~ an abnormal sign detection, ~~and acquiring~~

~~vibration data detected by a vibration sensor among the sensor data in a designated step of a plurality of steps constituting a process recipe;~~

~~(b) acquiring a second set of sensor data whose data amount is smaller than that of the first set of sensor data;~~

5 ~~(c) determining whether to use the normal model by statistically determining whether or not a distribution of the second set of sensor data is equal to that of the normal model; and~~

~~—— (b) converting the acquired vibration data into a vibration frequency spectrum;~~

~~—— (c) extracting frequencies in a predetermined range of the converted vibration frequency spectrum at predetermined frequency intervals, and calculating an average value and a standard deviation of an amplitude of the vibration frequency spectrum for each extracted frequency by using data of the process recipe executed a predetermined number of times under a normal state;~~

10 ~~—— (d) re-creating the normal model by using the average value and the standard deviation of the amplitude of the vibration frequency spectrum; and~~

15 ~~(d) detecting an abnormal sign before an abnormal apparatus stop occurs by monitoring an apparatus state based on the normal model if it is determined that the normal model is to be used.~~

20 [Claim 11]

~~—— A method of manufacturing a semiconductor device by performing a predetermined process on a substrate by executing a process recipe constituted by a~~

plurality of steps, the method comprising:

———(a) acquiring sensor data of various sensors provided in at least one among an apparatus and an ancillary equipment of the apparatus while executing the process recipe;

5 ———(b) acquiring vibration data detected by a vibration sensor among the sensor data of the various sensors in a designated step of the plurality of steps constituting the process recipe;

———(c) converting the acquired vibration data into a vibration frequency spectrum;

10 ———(d) extracting frequencies in a predetermined range of the converted vibration frequency spectrum at predetermined frequency intervals, and calculating an average value and a standard deviation of an amplitude of the vibration frequency spectrum for each extracted frequency by using data of the process recipe executed a predetermined number of times under a normal state;

15 ———(e) creating a normal model by using the average value and the standard deviation of the amplitude of the vibration frequency spectrum, comparing an amplitude value of the normal model with a predetermined threshold value for the extracted frequency, and determining that an abnormal sign is present when the number of amplitude values of frequencies deviating from the predetermined threshold value is equal or greater than a predetermined number.

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[Claim 12]

———A sign detection program executed by a substrate processing apparatus comprising a main controller configured to control an execution of a predetermined

process on a substrate by executing a process recipe constituted by a plurality of steps and a sign detector configured to acquire sensor data of various sensors provided in at least one among the substrate processing apparatus and an ancillary equipment of the substrate processing apparatus to monitor an apparatus state, wherein the sign detection
5 program causes, by a computer, the substrate processing apparatus to perform:

——— (a) acquiring the sensor data while executing the process recipe;

——— (b) acquiring vibration data detected by a vibration sensor among the sensor data of the various sensors in a designated step of the plurality of steps constituting the process recipe;

10 ——— (c) converting the acquired vibration data into a vibration frequency spectrum;

——— (d) extracting frequencies in a predetermined range of the converted vibration frequency spectrum at predetermined frequency intervals, and calculating an average value and a standard deviation of an amplitude of the vibration frequency spectrum for each extracted frequency by using data of the process recipe executed a predetermined
15 number of times under a normal state;

——— (e) creating a normal model by using the average value and the standard deviation of the amplitude of the vibration frequency spectrum, comparing an amplitude value of the normal model with a predetermined threshold value for the extracted frequency, and determining that an abnormal sign is present when the number of
20 amplitude values of frequencies deviating from the predetermined threshold value is equal to or greater than a predetermined number.

[Claim 13]

———A substrate processing apparatus comprising:

———a main controller configured to control an execution of a predetermined process on a substrate by executing a process recipe constituted by a plurality of steps; and

———a sign detector configured to acquire sensor data of various sensors provided in

5 at least one among the substrate processing apparatus and an ancillary equipment of the substrate processing apparatus to monitor an apparatus state,

———wherein the sign detector is further configured to:

———acquire vibration data detected by a vibration sensor among the sensor data of the various sensors in a designated step of the plurality of steps constituting the process

10 recipe;

———convert the acquired vibration data into a vibration frequency spectrum;

———extract frequencies in a predetermined range of the converted vibration frequency spectrum at predetermined frequency intervals, and calculate an average value and a standard deviation of an amplitude of the vibration frequency spectrum for

15 each extracted frequency by using data of the process recipe executed a predetermined number of times under a normal state;

———create a normal model using the average value and the standard deviation of the amplitude of the vibration frequency spectrum;

———compare an amplitude value of the normal model with a predetermined

20 threshold value for the extracted frequency; and

———determine that an abnormal sign is present when the number of amplitude values of frequencies deviating from the predetermined threshold value is equal to or greater than a predetermined number.

[Claim 14]

———A substrate processing apparatus configured to acquire sensor data related to a component subject to an abnormal sign detection, to create a normal model and to
5 monitor an apparatus state based on the normal model, the substrate processing apparatus comprising

———a sign detector configured to acquire the sensor data after a replacement or a maintenance of the component subject to the abnormal sign detection, to re-create the normal model based on the acquired sensor data, to monitor the apparatus state based on
10 the normal model, and to detect an abnormal sign before an abnormal apparatus stop occurs,

———wherein the sign detector is further configured to determine, based on the sensor data whose data amount is smaller than an amount of data for creating the normal model, whether or not the normal model before the replacement or the maintenance is
15 appropriate to be used as the normal model after the replacement or the maintenance.

[Claim 15]

———A sign detection program executed by a substrate processing apparatus configured to acquire sensor data related to a component subject to an abnormal sign
20 detection, to create a normal model and to monitor an apparatus state based on the normal model, wherein the sign detection program causes, by a computer, the substrate processing apparatus to perform:

———(a) acquiring the sensor data after a replacement or a maintenance of the

~~component subject to the abnormal sign detection and re-creating the normal model based on the acquired sensor data; and~~

~~—— (b) monitoring the apparatus state based on the normal model, and detecting an abnormal sign before an abnormal apparatus stop occurs;~~

5 ~~—— wherein (b) comprises~~

~~—— determining, based on sensor data whose data amount is smaller than an amount of data required to create the normal model, whether or not the normal model before the replacement or the maintenance is appropriate to be used as the normal model after the replacement or the maintenance.~~

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~~[Claim 16]~~

~~—— A method of manufacturing a semiconductor device, comprising:~~

~~—— (A) acquiring sensor data related to a component subject to an abnormal sign detection, creating a normal model and monitoring an apparatus state based on the normal model; and~~

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~~—— (B) processing a substrate,~~

~~—— wherein (A) comprises:~~

~~—— (a) acquiring the sensor data after a replacement or a maintenance of the component subject to the abnormal sign detection and re-creating the normal model based on the acquired sensor data; and~~

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~~—— (b) monitoring the apparatus state based on the normal model, and detecting an abnormal sign before an abnormal apparatus stop occurs;~~

~~—— wherein (b) comprises~~

~~—determining, based on sensor data whose data amount is smaller than an amount of data required to create the normal model, whether or not the normal model before the replacement or the maintenance is appropriate to be used as the normal model after the replacement or the maintenance.~~