[CLAIMS]

[Claim 1]

A substrate processing apparatus comprising:

a boat on which substrates are placed;

a process furnace comprising a reaction tube into which the boat is to be inserted, wherein a film is formed on the substrates placed on the boat in the reaction tube;

a substrate transport device configured to transfer the substrates into the boat; and

a controller configured to control the substrate transport device,

wherein the substrates are transferred into the boat by the substrate transport device referring to a virtual center axis of the reaction tube measured in advance,

wherein the controller is further configured to control the substrate transport device such that a center position of each of the substrates transferred into the boat by the substrate transport device is located between a center axis of the boat and the virtual center axis of the reaction tube, and the center position falls within a range from the center axis of the boat wherein a safety factor equal to or higher than a predetermined level is satisfied in the range.

[Claim 2]

The substrate processing apparatus of claim 1, wherein the process furnace further comprises a rotator configured to rotate the boat by placing the boat on a rotating shaft when the boat is inserted in the reaction tube, and

wherein the controller is further configured to store information on a difference between a rotation axis of the rotating shaft and the virtual center axis of the reaction tube measured in advance.

[Claim 3]

The substrate processing apparatus of claim 2, wherein the controller is further configured to obtain transfer position coordinates P0 for each of the substrates to be safely inserted into the boat.

[Claim 4]

The substrate processing apparatus of claim 3, wherein the controller is further configured to use, as a geometric information of the rotation axis, a result of fitting the transfer position coordinates P0 obtained for a part of the substrates onto a straight line or a solid of revolution.

[Claim 5]

The substrate processing apparatus of claim 3, wherein the controller is further configured to calculate the transfer position coordinates P0 based on a detection result of a sensor attached to the substrate transport device.

[Claim 6]

The substrate processing apparatus of claim 4, wherein the controller is further configured to obtain the transfer position coordinates P0 at least three times by changing rotation angle of the boat and to fit the transfer position coordinates P0 onto the solid of revolution.

[Claim 7]

The substrate processing apparatus of claim 2, wherein the controller is further configured to control the substrate transport device, when the center position falls within the range from the center axis of the boat wherein the safety factor equal to or higher than the predetermined level is satisfied in the range, such that the center position of each of the substrates transferred into the boat by the substrate transport device is located at the virtual center axis of the reaction tube.

[Claim 8]

The substrate processing apparatus of claim 2, wherein the reaction tube is embodied by a double tube structure comprising an outer tube and an inner tube, and

wherein the virtual center axis of the reaction tube is obtained by measuring a shape of an inner surface of the inner tube based on the rotating shaft of a rotating shaft body as a reference axis.

[Claim 9]

The substrate processing apparatus of claim 2, wherein a rotating shaft body is provided with an opening configured to communicate with an inside and an outside of the reaction tube and provided coaxially with the rotating shaft of the rotating shaft body,

wherein the controller is further configured to use the virtual center axis of the reaction tube determined based on data from a sensor inserted through the opening and configured to obtain a shape of an inner surface of the reaction tube.

[Claim 10]

A method of manufacturing a semiconductor device comprising:

(a) transferring substrates into a boat by a substrate transport device based on a virtual center axis of a reaction tube as a reference axis wherein the boat is to be inserted into the reaction tube;

(b) inserting the boat into the reaction tube by a boat elevator; and

(c) processing the substrates by supplying a gas into the reaction tube while rotating the boat,

wherein in the (a), the substrate transport device is controlled such that a center position of each of the substrates transferred into the boat by the substrate transport device is located between a center axis of the boat and the virtual center axis of the reaction tube, and the center position falls within a range from the center axis of the boat wherein a safety factor equal to or higher than a predetermined level is satisfied in the range.