

SUBSTRATE PROCESSING APPARATUS, METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE, AND PROGRAM

TECHNICAL FIELD

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

BACKGROUND

[0002] In a substrate processing apparatus such as a vertical forming-film apparatus, a substrate holder (hereinafter also referred to as a boat) on which a plurality of substrates (hereinafter, also referred to as wafers) are mounted is accommodated in a process chamber, a process gas is supplied and heated, the internal pressure and temperature of the process chamber are set to predetermined values, and various processes are performed to the substrate surface. In such a substrate processing apparatus, for example, in a case where the process gas is introduced into a process furnace and processed in a state where a dummy substrate (hereinafter also referred to as a dummy wafer) and a product substrate (hereinafter also referred to as a product wafer) are mixed, it has been found that the film thickness deposited over the product substrate fluctuates depending on the number of product substrates mounted on the boat. For example, as described in Patent Document 1 below, a recipe is prepared using control parameters according to the number of products. As another example, as described in Patent Document 2 below, a screen for setting a substrate accommodation position can be displayed, and various combinations of the type, position and number of substrates can be set. However, changing transfer position and the number of dummy substrates according to the number of products requires the preparation of a combination of the type, position and number of substrates each time, which takes time and labor.

[Prior Art Documents]

[0003] Patent Documents

Patent Document 1: Japanese laid-open publication No. 2014-075574

SUMMARY

[0004] The present disclosure provides some embodiments of a configuration for operating a substrate transfer mechanism so as to obtain appropriate substrate arrangement.

[0005] According to one or more embodiments of the present disclosure, there is provided a configuration including; a substrate holder configured to hold a plurality of substrates including product substrates and dummy substrates; a transfer mechanism configured to load the plurality of substrates to the substrate holder; a main controller configured to determine substrate-mounting positions for the plurality of substrates according to setting items respectively corresponding to the number of the product substrates to be mounted on the substrate holder, the number of the dummy substrates to be loaded above and below the product substrates, and a number indicating a mounting position of a topmost of the dummy substrates to be loaded to the substrate holder; and a transfer controller configured to operate the transfer mechanism according to the determined substrate-mounting positions.

[0006] According to the present disclosure, it is possible to operate the substrate transfer mechanism so as to obtain appropriate substrate arrangement.

BRIEF DESCRIPTION OF DRAWINGS

[0007] FIG. 1 is a perspective view of a substrate processing apparatus according to embodiments of the present disclosure.

FIG. 2 is a side perspective view of the substrate processing apparatus according to the embodiments of the present disclosure.

FIG. 3 is a configuration example of a controller and a storage part of the substrate processing apparatus according to the embodiments of the present disclosure.

FIG. 4 is a view for explaining first embodiments of the present disclosure.

FIG. 5 is an example of a setting screen for setting predetermined items according to second and

third embodiments of the present disclosure.

FIG. 6A is a view showing an example in which a substrate is mounted based on the settings in FIG. 5.

FIG. 6B is a view showing an example in which a substrate is mounted based on the settings in FIG. 5.

FIG. 6C is a view showing an example in which a substrate is mounted based on the settings in FIG. 5.

FIG. 7 is an illustrative example of a flowchart according to embodiments of the present disclosure.

FIG. 8 is a view for explaining fourth embodiments of the present disclosure.

DETAILED DESCRIPTION

[0008] A substrate processing apparatus according to embodiments of the present disclosure will now be described with reference to the drawings. In the present embodiments, as an example, the substrate processing apparatus is configured as a semiconductor manufacturing apparatus that carries out processes in a method of manufacturing a semiconductor device (IC: Integrated Circuit). In the following description, as a substrate processing apparatus, a batch type vertical semiconductor manufacturing apparatus (hereinafter simply referred to as a processing apparatus) for performing an oxidation process, a diffusion process, a CVD process and the like on a substrate will be described. FIG. 1 is a perspective view of a processing apparatus to which the present disclosure is applied. FIG. 2 is a side perspective view of the processing apparatus shown in FIG. 1.

[0009] As shown in FIGS. 1 and 2, a processing apparatus 100 of the present embodiments uses a pod 110 as a carrier for storing a wafer (substrate) 200 made of silicon or the like, and includes a housing 111. A pod-loading/unloading port 112 is formed over the front wall 111a of the housing 111 so as to communicate the inside and outside of the housing 111, and is opened and closed by a front shutter 113. A load port 114 is installed at the front side of the pod-

loading/unloading port 112, and the pod 110 is mounted on the load port 114. The pod 110 is loaded to the load port 114 by an in-process transfer device (not shown) and is unloaded from the load port 114.

[0010] A rotating shelf 105 is installed at an upper portion in a substantially central portion in a front-rear direction in the housing 111. The rotating shelf 105 rotates around a support 116 and stores a plurality of pods 110 in a shelf board 117. As shown in FIG. 2, a pod transfer device 118 is installed between the load port 114 and the rotating shelf 105 in the housing 111. The pod transfer device 118 includes a pod elevator 118a that can move up and down while holding the pod 110, and a pod transfer mechanism 118b as a horizontal transfer mechanism, and transfers the pod 110 between the load port 114, the rotating shelf 105, and a pod opener 121.

[0011] As shown in FIG. 2, at the lower portion in the substantially central portion in the front-rear direction in the housing 111, a sub housing 119 is constructed across the rear end. At the front wall 119a of the sub housing 119, a pair of wafer-loading/unloading ports 120 for loading/unloading the wafer 200 into/from the sub housing 119 is vertically arranged in upper and lower stages. A pair of pod openers 121 is installed at the upper and lower wafer-loading/unloading ports 120, respectively. The pod opener 121 includes a mounting table 122 on which the pod 110 is mounted, and a cap-attaching/detaching mechanism 123 for attaching/detaching a cap (lid) of the pod 110. The pod opener 121 opens/closes the wafer-loading/unloading port of the pod 110 by attaching/detaching the cap of the pod 110 mounted on the mounting table 122 by the cap-attaching/detaching mechanism 123. The mounting table 122 is a transfer shelf on which a substrate container is mounted when a substrate is transferred.

[0012] As shown in FIG. 2, the sub housing 119 constitutes a transfer chamber 124 isolated from the atmosphere of the installation space of the pod transfer device 118 and the rotating shelf 105. A wafer transfer mechanism 125 is installed in the front area of the transfer chamber 124. The wafer transfer mechanism 125 includes a wafer transfer device 125a, which mounts the wafer 200 on a tweezer 125c and can rotate or translate in the horizontal direction, and a wafer transfer device elevator 125b for moving the wafer transfer device 125a up and down. The wafer 200 is

loaded/unloaded to/from the boat 217 by the continuous operation of the wafer transfer device elevator 125b and the wafer transfer device 125a.

[0013] As shown in FIG. 1, a clean unit 134 configured by a supply fan and a dustproof filter is installed in the transfer chamber 124 so as to supply clean air 133 which is a clean atmosphere or an inert gas. As shown in FIG. 2, a process furnace 202 is installed above the boat 217. The process furnace 202 internally includes a substrate process chamber (not shown, hereinafter referred to as a process chamber), and a heater (not shown) for heating an inside of the process chamber is installed around the process chamber. The lower end portion of the process furnace 202 is opened and closed by a furnace port gate valve 147.

[0014] As shown in FIG. 1, a boat elevator 115 is installed to raise and lower the boat 217. A seal cap 219 is horizontally installed at an arm 128 connected to the boat elevator 115. The seal cap 219 is configured to vertically support the boat 217 and to close the lower end of the process furnace 202. The boat 217 is a substrate holder provided with a plurality of posts on which grooves (hereinafter also referred to as slots) for loading a plurality of (for example, about 30 to 125) wafers 200 are engraved. The boat 217 is configured to hold the wafers 200 horizontally with their centers aligned vertically. A plurality of side dummy wafers is mounted on the upper end portion and the lower end portion of the boat 217, and product wafers are mounted between the side dummy wafer on the upper end side and the side dummy wafer on the lower end side. The same side dummy wafers are repeatedly used while a batch process is performed multiple times while exchanging the product wafers.

[0015] Next, the operation of the processing apparatus of the present embodiments will be described. As shown in FIGS. 1 and 2, when the pod 110 is supplied to the load port 114, the pod-loading/unloading port 112 is opened by the front shutter 113, and the pod 110 is loaded from the pod-loading/unloading port 112. The loaded pod 110 is automatically transferred and delivered by the pod transfer device 118 to a designated shelf board 117 of the rotating shelf 105.

[0016] The pod 110 is temporarily stored in the rotating shelf 105 and then transferred from the shelf board 117 to one pod opener 121 and transferred to the mounting table 122 or transferred

directly from the load port 114 to the pod opener 121 and transferred to the mounting table 122. At this time, the wafer-loading/unloading port 120 of the pod opener 121 is closed by the cap-attaching/detaching mechanism 123, and clean air 133 is circulated and filled in the transfer chamber 124.

[0017] As shown in FIG. 2, the cap of the pod 110 mounted on the mounting table 122 is removed by the cap-attaching/detaching mechanism 123, and the wafer entrance of the pod 110 is opened. The wafer 200 is picked up from the pod 110 by the wafer transfer mechanism 125 and transferred to and loaded on the boat 217. The wafer transfer mechanism 125 which has delivered the wafer 200 to the boat 217 returns to the pod 110 and loads the next wafer 200 to the boat 217.

[0018] During the operation of loading the wafer 200 to the boat 217 by the wafer transfer device 125a in the one (upper or lower) pod opener 121, in the other (lower or upper) pod opener 121, another pod 110 is transferred by the pod transfer device 118 from the rotating shelf 105 or the load port 114, and the operation of opening the another pod 110 by the pod opener 121 is simultaneously performed.

[0019] When a predetermined number of wafers 200 are loaded to the boat 217, the lower end of the process furnace 202 is opened by the furnace port gate valve 147. Subsequently, the seal cap 219 is raised by the boat elevator 115, and the boat 217 supported by the seal cap 219 is loaded to the process chamber in the process furnace 202. After the loading, any process is performed to the wafers 200 in the process chamber. After the process, the boat 217 is pulled out by the boat elevator 115, and thereafter, the wafers 200 and the pod 110 are discharged to the outside of the housing 111 in the reverse of the above-described procedure.

[0020] Next, the configurations of the controller and the storage part of the substrate processing apparatus will be described with reference to FIG. 3. FIG. 3 shows a configuration example of the controller and the storage part of the substrate processing apparatus according to the present embodiments. As shown in FIG. 3, the controller 10 includes a main controller 11, a temperature controller 12, a gas flow rate controller 13, a pressure controller 14, and a transfer

controller 15. The main controller 11 is electrically connected with the components that constitute the substrate processing apparatus 100, such as the temperature controller 12, the gas flow rate controller 13, the pressure controller 14, the transfer controller 15, an operation part 31 for receiving instructions from an operator, a display part 32 that displays an operation screen and information such as various data, and a storage part 20 that stores a process recipe which is a substrate-processing sequence of the substrate processing apparatus 100, etc. The operation part 31 and the display part 32 can be integrally configured, for example, in the case of a touch panel or the like.

[0021] The temperature controller 12 is configured to control the temperature of a heater that heats the process furnace 202. The temperature controller 12 receives temperature data from a temperature sensor that measures the internal temperature of the process furnace 202, and transmits the temperature data to the main controller 11. Further, the temperature controller 12 receives, from the main controller 11, for example, a heating temperature instruction of the heater that raises the internal temperature of the process furnace 202, and heats the heater so as to reach the instructed temperature.

[0022] The gas flow rate controller 13 receives gas flow rate data from, for example, an MFC (hereinafter also referred to as a flow rate controller) installed at a process gas supply pipe that supplies a process gas into the process furnace 202, and transmits the gas flow rate data to the main controller 11. Further, the main controller 11 receives a gas control instruction such as a valve open/close instruction of an opening/closing valve installed at the process gas supply pipe or a pump drive instruction, and controls a gas flow rate according to the instruction.

[0023] The pressure controller 14 receives information on the internal pressure of the process furnace 202 from a pressure sensor installed at an exhaust pipe for exhausting a gas from the interior of the process furnace 202, and transmits the information to the main controller 11. Further, the main controller 11 receives a valve opening instruction and a pump drive instruction of a pressure adjustment valve, a pump, etc. installed at the exhaust pipe, and controls the internal pressure of the process furnace 202 according to the instructions. Thus, based on the

pressure detected by the pressure sensor, the controller 10 controls the internal pressure of the process chamber at a desired timing so that the internal pressure of the process chamber becomes a desired pressure by a pressure adjustment device.

[0024] The transfer controller 15 is configured to control the positions of the pod transfer device 118, the wafer transfer mechanism 125, the boat elevator 115, etc. The transfer controller 15 is electrically connected with a photo sensor (not shown) and a pod sensor (not shown) and receives data such as the presence/absence and the position of the pod 110 accommodating the wafer 200 from these sensors, and transmits the data to the main controller 11. Further, the transfer controller 15 receives a transfer instruction of, for example, the pod 110, the boat 217, and the wafer 200 from the main controller 11, and transfers the pod 110, the boat 217, and the wafer 200 to the instructed location or position.

[0025] The main controller 11 includes a CPU (Central Processing Unit) and a memory that stores an operation program of the main controller 11, as a hardware configuration. The CPU operates to download the recipe stored in the storage part 20 to the memory and execute the recipe according to the operation program based on an instruction of the operator from the operation part 31. At this time, the main controller 11 causes the sub controllers such as the temperature controller 12, the gas flow rate controller 13, the pressure controller 14, and the transfer controller 15 to measure the temperature, pressure, gas flow rate, etc. in the process chamber, outputs a control signal to each sub controller based on the measurement data, and controls each sub controller to operate according to the recipe.

[0026] The storage part 20 is configured by an EEPROM, a flash memory, a hard disk or the like, and includes a storage medium storing the operation program of the CPU and a storage medium storing the recipe. The operation program stored in the storage part 20 is transmitted to the memory of the main controller 11 and operated, for example, when the substrate processing apparatus starts to operate.

[0027] As shown in FIG. 3, the storage part 20 includes at least a recipe storage part 21, a WAP (Wafer Arrangement Parameter) storage part 22, a process condition storage part 23, and a job

storage part 24.

[0028] The recipe storage part 21 stores a plurality of types of recipes including a process recipe for performing substrate processing, for example, a recipe A for forming a film of thickness A over the surface of the wafer 200 and a recipe B for forming a film of thickness B over the surface of the wafer 200. One recipe usually includes a plurality of process steps, each of which includes a plurality of process parameters for processing the substrate 200. The WAP storage part 22 stores at least contents (setting items) such as the type (product, dummy, etc.) of the wafer 200 to be transferred to the boat 217, the substrate transfer position (transfer start head slot number) as a substrate-mounting position, the number of substrates, etc. determined by the operator. In this manner, the WAP storage part 22 includes a plurality of combinations of the number of product substrates, the head slot number, the number of upper dummy substrates, and the number of lower dummy substrates when the substrates 200 is processed. Furthermore, in the WAP storage part 22, when the number of product substrates 200 is smaller than the number (that can be held) of slots in the boat 217, information such as the presence/absence and number of supplementary dummy substrates and the transfer presence/absence and number of monitor substrates 200 is also included in each setting item. Further, information such as the number and position of upper and lower side dummy substrates may be included in each setting item.

[0029] The process condition storage part 23 stores, as process condition management information, a process condition such as the number of product substrates to be mounted on the boat 217, and the accumulated film thickness deposited on the boat 217, the furnace wall of the process furnace 202, and the dummy substrate in a job to be executed. The process condition management information can be input and set by the operator from the operation part 31, for example. A job refers to a series of processes in which a plurality of product substrates are mounted on the boat 217, loaded into the process furnace 202, processed in the process furnace 202, and then unloaded from the process furnace 202, and the product substrates are taken out from the boat 217.

[0030] The job storage part 24 stores the recipe name to be used in the job to be executed, the

start order or start time of the job, and the like. The matching uses an automatically generated ID called a job ID. For example, the job storage part 24 stores the job ID, the recipe name "Test," and the serial number "002" indicating the start order or the start time "14:00" in matching. Hereinafter, the job may be referred to as a process recipe.

[0031] Next, the substrate arrangement sequence in the present embodiments will be described with reference to FIG. 7. In the present embodiments, the substrate transfer to the boat 217 is executed, but the substrate processing (process recipe) after the substrate transfer may also be executed.

[0032] (S1) When at least a predetermined number of product substrates 200 are loaded into the substrate processing apparatus 100 and the controller 10 receives an instruction to process the product substrates 200 from a host computer or the operation part 31, the substrate arrangement sequence in the present embodiments is started.

[0033] (S2) The controller 10 acquires, from the storage part 20, various data for arranging (laying out) substrates on the boat 217. Specifically, the controller 10 acquires data including an appropriate transfer condition among the data stored in the WAP storage part 22.

Alternatively, the controller 10 may appropriately display a setting table shown in FIG. 4 or 5 to be described below on the display part 32 to obtain data for substrate layout preparation from the operator.

[0034] (S3) After acquiring various data in S2, the controller 10 checks whether or not a setting table of a setting item (parameter) corresponding to the number of product substrates 200 is valid. Specifically, the controller 10 checks from which setting table of the example of the setting table shown in FIG. 4 or 5 to be described later, the data for arranging the substrates is acquired.

[0035] The controller 10 proceeds to (S7) when NO in S3 (acquiring data in the example of the setting table shown in FIG. 4). In this case, regardless of the number of product substrates 200, the arrangement of the substrates is determined according to the contents of the setting item (parameter). Specifically, when processing the product substrates 200, the arrangement of the substrates is determined according to a combination of the head slot No., the number of upper

dummy substrates, and the number of lower dummy substrates.

[0036] (S4) When YES in S3 (acquiring data in the example of the setting table shown in FIG. 5), the controller 10 determines the arrangement of the substrates according to the contents of setting item (parameter) according to the number of product substrates 200. First, the number of product substrates 200 is checked. (S5) Next, the number of dummy substrates and the head position according to the number of product substrates 200 are selected from the setting table.

[0037] (S6) The controller 10 compares the number of dummy substrates and the head position with the data for substrate layout preparation acquired in (S2). In this case, the arrangement of the substrates is determined according to the contents of setting item (parameter) according to the number of product substrates 200 as they are. Specifically, (S7) the controller 10 determines the arrangement of the substrates according to a combination of the number of product substrates, the head slot No., the number of upper dummy substrates, and the number of lower dummy substrates when processing the product substrates 200.

[0038] (S8) The controller 10 sends to the transfer controller 15 the arrangement of the substrates determined according to the combination of the number of product substrates, the head slot No., the number of upper dummy substrates, and the number of lower dummy substrates when processing the product substrates 200. The transfer controller 15 controls the wafer transfer mechanism 125 to transfer the substrates 200 to the boat 217 according to the determined substrate-mounting position.

[0039] Although not shown, after the transfer step (S8) of transferring the substrates 200 to the boat 217, the controller 10 acquires a process recipe from the recipe storage part 21 and executes the process recipe to perform a step of processing the substrates 200.

(First Example)

[0040] Next, a first Example in which at least one is selected from a group consisting of the type of substrate 200 to be transferred to the boat 217, the mounting position of the substrate 200, and the number of substrates 200 and the wafer transfer mechanism 125 is controlled according to the selected condition will be described with reference to FIG. 4. FIG. 4A is an example of a

screen of a setting table that sets any of the head slot No. as a number indicating the substrate-mounting position of the upper end mounted on the substrate holder, at which the mounting of the upper dummy substrate 200a is started, the number of upper dummy substrates 200a as dummy substrates to be mounted from the number indicating the substrate-mounting position of the upper end, and the number of lower dummy substrates 200c as dummy substrates to be mounted from a number indicating the substrate-mounting position of the lower end mounted on the substrate holder. FIG. 4B shows an example in which upper and lower dummy substrates 200a and 200c and a product substrate 200b are mounted on the boat 217 according to the head slot No. at which the mounting of the upper dummy substrate 200a is started, the number of upper dummy substrates 200a, and the number of lower dummy substrates 200c, set in FIG. 4A. In the process according to the first Example, the product substrate 200b is mounted between the upper end dummy substrate 200a and the lower end dummy substrate 200c. For example, when receiving the material information including at least the substrate transfer position determined with the number of product substrates designated by the operation of the operator, the main controller 11 transfers the substrates 200 to the boat 217 according to the substrate transfer position.

[0041] First, the operator uses the operation part 31 to preset at least one of the head slot No. at which the mounting of the upper dummy substrate 200a is started, the number of upper dummy substrates 200a, and the number of lower dummy substrates 200c, on a setting screen for setting a predetermined condition for loading the substrates 200 on the substrate holder 217 displayed on the display part 32. FIG. 4A shows an example in which the head slot No. at which transfer of the upper dummy substrate 200a is started is 120, the number of upper dummy substrates 200a is 10, and the number of lower dummy substrates 200c is 5. With this setting, the main controller 11 in the controller 10 causes the wafer transfer mechanism 125 to mount the set number of substrates of the set type at a set position. In this Example, regardless of the number of product substrates, the head slot No. at which the mounting of the upper side dummy substrate 200a is started, the number of upper side dummy substrates 200a, and the number of lower side

dummy substrates 200c are fixed in advance.

[0042] FIG. 4B shows a state in which the substrate holder 217 is controlled by the control of the controller 10 based on the setting value input in the present Example, and a substrate is transferred to a set substrate transfer position.

[0043] According to the first Example described above, regardless of the number of product substrates, since the head slot No. which is the mounting start position of the upper dummy substrate, the number of upper dummy substrates, and the number of lower dummy substrates are registered in advance in the storage part 20 (the WAP storage part 22), it is possible to suppress input miss of parameters by the operator.

(Second Example)

[0044] Next, a second Example in which the mounting position and the number of dummy substrates are determined in accordance with the number of product substrates will be described with reference to FIGS. 5 and 6. FIG. 5 shows a table in which the number of product substrates, the head slot No. at which the mounting of the upper dummy substrate is started, the number of upper dummy substrates, and the number of lower dummy substrates are set. The operator selects the number of product substrates from the operation part 32. Based on the head slot No. at which the mounting of the dummy substrate is started, the number of upper dummy substrates, and the number of lower dummy substrates according to the selected number of product substrates, the main controller 11 controls the transfer mechanism 125 to mount the dummy substrates and the product substrates. FIG. 6A shows an example in which the number of product substrates is selected to be 25, FIG. 6B shows an example in which the number of product substrates is selected to be 75, and FIG. 6C shows an example in which the number of product substrates is set to be 200. Even in the process according to the Example, as shown in FIGS. 6A to 6C, the product substrate 200b is mounted between the dummy substrate 200a on the upper end side and the dummy substrate 200c on the lower end side. For example, when receiving the material information including at least the substrate transfer position determined with the number of product substrates designated by the operation by the operator, the main

controller 11 refers to a setting screen (for example, FIG. 5) to check whether or not the number of product substrates is designated, and if designated, selects a parameter according to the number of product substrates, and determines the substrate transfer position.

[0045] Further, although the number of product substrates is used as the process condition in the above-described Example, it is also possible to set the number of substrates obtained by totaling the number of dummy substrates and the number of product substrates as the process condition according to the process.

[0046] According to the second Example described above, the effects of the first Example and at least one of the following effects (1) to (3) can be obtained.

(1) Since the substrate processing apparatus automatically selects a process parameter adapted to the number of product substrates at the time of executing the recipe, it is possible to suppress a setting miss of the process parameter by the operator. In addition, film thickness control corresponding to the number of product substrates is facilitated, and the occurrence of lot-out of product substrates can be suppressed.

(2) Even when the number of product substrates fluctuates for each process, by designating the appropriate substrate arrangement, the fluctuation of film thickness deposited on the product substrates due to the fluctuation of the number of product substrates can be suppressed, and the stability of product quality can be improved.

(3) Since it is not necessary to separate the WAP according to the number of product substrates, it is possible to shorten the working time of the operator.

(Third Example)

[0047] A third Example is embodiments in which the dummy substrates in the second Example are replaced with a pattern dummy substrate. Hereinafter, only differences from the second Example and portions requiring supplementary explanation will be described. Here, the pattern dummy substrate is a substrate on which a predetermined pattern is formed on a surface like a product substrate in which a fine pattern is formed on the surface of a normal dummy substrate.

[0048] The flowchart of the controller 10 in the third Example shifts to (S7) as the first Example

when the parameter setting table (FIG. 5) corresponding to the number of product substrates is not valid in S3 of FIG. 7, and then, regardless of the number of product substrates 200, the arrangement of substrates is determined according to the contents of the setting item (parameter) acquired in (S2).

[0049] Further, the controller 10 determines the arrangement of substrates according to a combination of the number of product substrates, the head slot No., the number of upper pattern dummy substrates, and the number of lower pattern dummy substrates so that the pattern dummy substrates in the third Example are arranged as shown in FIG. 6. The number of dummy substrates shown in FIGS. 5 and 6 is an example, and the number is not limited to this value but may be set as appropriate.

[0050] Even if dummy substrates used up to now are placed above and below a product substrate for ultra-fine patterns in addition to the recent various types and small-lot production, consumption of a process gas on a substrate surface in the process furnace 202 clearly differs and a desired process cannot be carried out. However, according to the third Example, by inserting the upper and lower sides of a pattern wafer in a pattern dummy substrate by the substrate arrangement as shown in FIG. 6, the amount of gas consumption on the substrate surface can be matched and a desired process can be performed.

[0051] Further, according to the third Example, all slots of the boat 217 are not held by an expensive pattern dummy substrate. Furthermore, by changing the number of pattern dummy substrates loaded above and below according to the number of product substrates, or by making the number of pattern dummy substrates mounted on the upper side of the product substrate to be larger than the number of pattern dummy substrates mounted on the lower side of the product substrate, the appropriate number of pattern dummy substrates can be used, and the cost can be reduced.

[0052] The third Example includes the effects of the first and second Examples.

(Fourth Example)

[0053] A fourth Example is embodiments in which a side dummy substrate 200s and a

supplementary dummy substrate 100f are transferred in addition to the third Example. As shown in FIG. 8, the supplementary dummy substrate 200f is transferred to each slot of the boat 217, and various substrates are transferred to all slots of the boat 217.

[0054] The fourth Example will be described mainly with reference to the flowchart shown in FIG. 7 in conjunction with FIGS. 4 and 5 as appropriate. Explanation of the same contents as in the first to third Example will be omitted.

[0055] (S1) When at least a predetermined number of product substrates 200 are loaded to the substrate processing apparatus 100 and the controller 10 receives an instruction to process the product substrates 200 from a host computer or the operation part 31, the substrate arrangement sequence in the present embodiments is started.

[0056] (S2) The controller 10 acquires, from the storage part 20, various data for arranging (laying out) substrates on the boat 217. Specifically, the controller 10 acquires data including an appropriate condition among the data stored in the WAP storage part 22. Alternatively, the controller 10 may appropriately display both the setting tables shown in FIGS. 4 and 5 on the display part 32 to obtain data for substrate layout preparation from the operator.

[0057] (S3) When the parameter setting table (FIG. 5) according to the number of product substrates is not acquired (No in S3), the controller 10 determines that the process is abnormal, forcibly terminates this flowchart, and issues an alarm to notify the occurrence of the abnormality. When YES in S3, the process proceeds to the next step.

[0058] (S4) When YES in S3 (acquiring data in the example of the setting table shown in FIG. 5), the controller 10 determines the arrangement of the substrates according to the contents of setting item (parameter) according to the number of product substrates 200. First, the number of product substrates 200 is checked. (S5) Next, the number of pattern dummy substrates and the head position of the pattern dummy substrates according to the number of product substrates 200 are selected from the setting table shown in FIG. 5.

[0059] (S6) The controller 10 compares the number of pattern dummy substrates and the head position of the pattern dummy substrates with data for substrate arrangement layout preparation

based on the setting table shown in FIG. 4, acquired in (S2), and determines the arrangement of pattern wafers and pattern dummy substrates in accordance with the contents of the setting item (parameter) corresponding to the number of product substrates 200.

[0060] (S7) The controller 10 determines the arrangement of the substrates according to a combination of the head slot No. at which various substrates specified in the setting table shown in FIG. 4 are mounted, the number of upper and lower side dummy substrates, the head slot No. of the pattern dummy substrates shown in FIG. 5, the number of product substrates, and the number of upper and lower pattern dummy substrates. Further, in the fourth Example, the data acquired in (S2) includes information using a supplementary dummy substrate, and as shown in FIG. 8, it is determined to arrange a supplementary dummy substrate in a slot between a side dummy substrate and a pattern dummy substrate.

[0061] (S8) The controller 10 sends to the transfer controller 15 the arrangement of the substrates determined according to a combination of the head slot No. of the upper side dummy, the number (10) of upper side dummy substrates, the number (5) of lower side dummy substrates, the presence and number of supplementary dummy substrates, the number of product substrates 200b to be processed, the head slot No. of the upper side pattern dummy substrate, the number of upper pattern dummy substrates, and the number of lower pattern dummy substrates. The transfer controller 15 controls the wafer transfer mechanism 125 to transfer the substrates 200 to the boat 217 according to the determined substrate-mounting position.

[0062] According to the fourth Example, the effects of the first and third Examples can be obtained.

[0063] Furthermore, according to the fourth Example, the process gas can be stabilized more than that in the third Example without generating convection of the process gas in the process furnace 202 by the supplementary dummy substrate, thereby improving the substrate-processing quality.

[0064] The present disclosure is not limited to the above-described embodiments, and it goes without saying that various modifications can be made without departing from the scope of the

present disclosure. The controller, the operation part, the display part, and the storage part for performing the VP process according to the first Example to the CP process according to the fourth Example described in the above embodiments may not be dedicated to the substrate processing apparatus, but may be implemented using, for example, a general computer system such as a computer (personal computer). For example, by installing a program for executing the above-described process in a general-purpose computer from a recording medium (flexible disk, CD-ROM, USB memory, etc.) storing the program, the controller, the operation part, the display part, and the storage part that execute the above-described process can be configured.

[0065] In addition, a means for supplying the program that executes the above-described process can be arbitrarily selected. In addition to supplying the program via a predetermined recording medium as described above, the program may be supplied via, for example, a communication line, a communication network, a communication system, and the like. In this case, for example, the program may be posted on a bulletin board of a communication network and supplied via the network. Then, the above-described process can be executed by activating the program provided thus and executing the program in the same manner as other application programs under the control of an OS (Operating System) of the substrate processing apparatus.

[0066] Furthermore, according to the first to fourth Examples, when a substrate holder on which a plurality of substrates are mounted is loaded into a process furnace and the substrates are processed, in the processing apparatus 100 in which dummy substrates corresponding to the number of substrates to be processed are supplemented and the substrate processing is performed, for example, even if films accumulated on the dummy substrates affects the substrate quality, it is possible to manage process parameters in consideration of the number of substrates to be processed and the accumulated film thickness deposited on the inner wall of the process furnace 202.

[0067] The present disclosure is applicable not only to a semiconductor manufacturing apparatus, but also to an apparatus for processing a glass substrate such as an LCD manufacturing apparatus, and other substrate processing apparatuses. In addition, the substrate processing apparatus of

the present disclosure may be of another type other than the vertical type, and in particular, it is preferable to apply to a multi-wafer type substrate processing apparatus provided with a substrate-mounting portion (susceptor) on which a plurality of substrates are mounted.

[0068] This application claims the benefit of priority based on Japanese Patent Application No. 2017-033214, filed Feb. 24, 2017, the entire disclosure of which is incorporated herein by reference.

INDUSTRIAL USE OF THE PRESENT DISCLOSURE

[0069] The present disclosure can be applied to a substrate processing apparatus in which a boat on which a plurality of substrates is mounted is accommodated in a process furnace and a process gas is supplied and heated to process the substrates.

EXPLANATION OF REFERENCE NUMERALS

[0070] 10: controller, 11: main controller, 15: transfer controller, 100: substrate processing apparatus, 125: wafer transfer mechanism, 200: wafer (substrate), 202: process furnace, 217: boat (substrate holder)

WHAT IS CLAIMED IS:

1. A substrate processing apparatus comprising:
 - a substrate holder configured to hold a plurality of substrates including product substrates and dummy substrates;
 - a transfer mechanism configured to load the plurality of substrates to the substrate holder;
 - a main controller configured to determine substrate-mounting positions for the plurality of substrates according to setting items respectively corresponding to a number of the product substrates to be mounted on the substrate holder, a number of the dummy substrates to be loaded above and below the product substrates, and a number indicating a mounting position of a topmost of the dummy substrates to be loaded to the substrate holder; and
 - a transfer controller configured to operate the transfer mechanism according to the determined substrate-mounting positions.
2. The substrate processing apparatus of Claim 1, further comprising: a storage part configured to store a setting table including the setting items,
 - wherein, when receiving material information including at least the number of the product substrates and the substrate-mounting positions, the main controller is configured to acquire the setting table corresponding to the material information.
3. The substrate processing apparatus of Claim 1, wherein the main controller is configured to check the number of the product substrates, select the setting items defined in the setting table according to the number of the product substrates, and determine substrate-mounting positions for the substrates according to the setting items.

4. The substrate processing apparatus of Claim 1, wherein the setting items are configured such that the number of the dummy substrates loaded above and below the product substrates are changed according to the number of the product substrates.

5. The substrate processing apparatus of Claim 4, wherein the setting items are configured such that a number of the dummy substrates to be mounted on an upper side of the product substrates is larger than a number of the dummy substrates to be mounted on a lower side of the product substrates.

6. The substrate processing apparatus of Claim 2, wherein the setting items are configured to be registered in advance in the storage part.

7. The substrate processing apparatus of Claim 1, further comprising: a setting screen on which the setting items for loading the plurality of substrates to the substrate holder are set according to the number of the product substrates,
wherein the main controller is configured to enable the setting items to be set on the setting screen.

8. The substrate processing apparatus of Claim 1, wherein the main controller is further configured to determine the substrate-mounting positions for the plurality of substrates according to setting items respectively corresponding to a number indicating a substrate-mounting position of an upper end to be mounted on the substrate holder, a number of side dummy substrates mounted from a number indicating the substrate-mounting position of the upper end, the number of side dummy substrates mounted from a number indicating a substrate-mounting position of a lower end to be mounted on the substrate holder, and a presence or absence of a supplementary dummy.

9. The substrate processing apparatus of Claim 9, wherein the number of the side dummy substrates is fixed.

10. The substrate processing apparatus of Claim 1, wherein the dummy substrates are pattern dummy substrates.

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

determining substrate-mounting positions for a plurality of substrates including product substrates and dummy substrates according to setting items respectively corresponding to a number of the product substrates to be mounted on a substrate holder that holds the plurality of substrates, a number of the dummy substrates to be loaded above and below the product substrates, and a number indicating a mounting position of a topmost of the dummy substrates to be loaded to the substrate holder;

transferring the plurality of substrates to the substrate holder according to the determined substrate-mounting positions; and

loading the substrate holder to a process furnace and processing the substrates held by the substrate holder.

12. A program for controlling a substrate processing apparatus by causing a computer to execute a process comprising:

determining substrate-mounting positions for a plurality of substrates including product substrates and dummy substrates according to setting items respectively corresponding to a number of the product substrates to be mounted on a substrate holder that holds the plurality of substrates, a number of the dummy substrates to be loaded above and below the product substrates, and a number indicating a mounting position of a topmost of the dummy substrates to be loaded to the substrate holder;

transferring the plurality of substrates to the substrate holder according to the determined substrate-mounting positions; and

processing the substrates held by the substrate holder in a state where the substrate holder is loaded to a process furnace.