

WAFER TRANSFER PLATFORM AND WAFER TRANSFER METHOD

TECHNICAL FIELD

The present invention belongs to the field of semiconductor technology, and relates to a wafer transfer platform and a wafer transfer method.

BACKGROUND

As one of the important metal interconnect apparatuses in integrated circuit manufacturing, electroplating apparatuses are generally evaluated from two aspects in terms of performance metrics: first, meeting various requirements of the electroplating process to achieve good electrical performance and high yield; second, achieving maximum output at the lowest cost. In the dual damascene electroplating process, a wafer is transferred from a wafer cassette to a process chamber by a front-end robot, and then sequentially enters an electroplating chamber and a cleaning chamber via a process robot. After the wafer completes electroplating and cleaning, the front-end robot transfers the wafer to an annealing chamber, and finally, the wafer is transferred back to the wafer cassette, thereby completing the entire electroplating process.

Amid the rapid development of the integrated circuit manufacturing industry, chip integration is becoming increasingly high, and the requirement for metal-film thickness also changes accordingly. The thinner a metal film, the shorter the required electroplating time, and correspondingly, the shorter the process time, thereby requiring a shorter response time of a robot. In existing electroplating apparatuses, one process robot is responsible for transferring all wafers to complete the electroplating and cleaning of the wafers in an electroplating chamber and a cleaning chamber. The robot has a complex travel path and a long response time, resulting in low wafer transfer efficiency.

Therefore, it is necessary to provide a wafer transfer platform and a wafer transfer method.

SUMMARY

In view of the above shortcomings of the prior art, the objective of the present

invention is to provide a wafer transfer platform and a wafer transfer method to solve the problem of low wafer transfer efficiency in the prior art.

To achieve the objective described above and other related objectives, a wafer transfer platform is provided, comprising:

a first process robot and a second process robot, for picking, placing, and transferring wafers;

a process chamber, including a plurality of reaction chambers arranged at different heights as a first layer and a second layer, the plurality of reaction chambers including first process chambers for performing a first treatment process on the wafers and second process chambers for performing a second treatment process on the wafers, and the plurality of reaction chambers being divided into a first region and a second region in a horizontal direction or a vertical direction;

wherein, the first process robot and the second process robot are respectively configured to transfer the wafers in the first region and the second region to transfer the wafers from the first process chambers to the second process chambers.

In one embodiment of the present invention, the reaction chambers located in the first region include at least one first process chamber and at least one second process chamber, and the reaction chambers located in the second region include at least one first process chamber and at least one second process chamber.

In one embodiment of the present invention, the number of at least one of the first process chamber and the second process chamber in each region is greater than 1.

In one embodiment of the present invention, the number of the first process chambers and the number of the second process chambers in each region are the same.

In one embodiment of the present invention, the first process chambers are electroplating chambers, and the second process chambers are cleaning chambers.

In one embodiment of the present invention, the first region and the second region are formed by dividing the plurality of reaction chambers in a horizontal direction, and

the first process robot and the second process robot transfer the wafers by rotational and/or translational movement.

In one embodiment of the present invention, the first region and the second region are formed by dividing the plurality of reaction chambers in a vertical direction, and the first process robot and the second process robot transfer the wafers by vertical and/or translational movement.

In one embodiment of the present invention, the first process robot and the second process robot are further configured to transfer the wafers from current first process chambers to idle second process chambers in corresponding regions.

In one embodiment of the present invention, the process robots are configured to transfer the wafers from current first process chambers to the second process chambers closest to the current first process chambers.

The present invention further provides a wafer transfer method, comprising the following steps:

transferring wafers from a wafer cassette to a temporary storage area by a front-end robot;

transferring the wafers from the temporary storage area to respective first process chambers among a plurality of reaction chambers in a first region and a second region of a process chamber by a first process robot and a second process robot, respectively, for performing a first treatment process;

transferring the wafers in corresponding regions by the first process robot and the second process robot, respectively, to transfer the wafers from the first process chambers among the plurality of reaction chambers to second process chambers for performing a second treatment process;

transferring the wafers from the second process chambers to the temporary storage area;

transferring the wafers from the temporary storage area back to the wafer cassette

by the front-end robot.

In one embodiment of the present invention, the first region and the second region are formed by dividing the plurality of reaction chambers in a horizontal direction, wherein the first process robot and the second process robot transfer the wafers by rotational and/or translational movement.

In one embodiment of the present invention, the first region and the second region are formed by dividing the plurality of reaction chambers in a vertical direction, wherein the first process robot and the second process robot transfer the wafers by vertical and/or translational movement.

In one embodiment of the present invention, in the step of transferring the wafers in corresponding regions by the first process robot and the second process robot, respectively, the first process robot and the second process robot transfer the wafers from current first process chambers to idle second process chambers in corresponding regions.

In one embodiment of the present invention, in the step of transferring the wafers in corresponding regions by the first process robot and the second process robot, respectively, the first process robot and the second process robot transfer the wafers from current first process chambers to the second process chambers closest to the current first process chambers.

As described above, in the wafer transfer platform of the present invention, the first process robot and the second process robot transfer wafers from first process chambers to second process chambers in a partitioned manner, so that the first process robot and the second process robot transfer the wafers in corresponding regions, simplifying the movement process of the process robots, shortening the stroke of the process robots, overcoming the defect caused by waiting for the process robots to transfer the wafers during wafer processing, greatly shortening the response time of the process robots, and achieving high throughput.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and performance of the present invention are further described by

the following embodiments and the accompanying drawings of the embodiments.

FIG. 1 is a schematic structural view of a wafer transfer platform according to an embodiment of the present invention.

FIG. 2 is a schematic structural view of a wafer transfer platform according to another embodiment of the present invention.

FIG. 3 is a flowchart of the wafer transfer method according to the present invention.

PREFERRED EMBODIMENTS OF THE INVENTION

The embodiments of the present invention are described below through specific examples, and those skilled in the art can easily understand other advantages and effects of the present invention from the content disclosed in this specification. The present invention can also be implemented or applied through other specific embodiments, and various modifications or changes can be made to the details in this specification based on different viewpoints and applications without departing from the spirit of the present invention.

In the detailed description of the embodiments of the present invention, cross-sectional views illustrating device structures may be partially enlarged for convenience of illustration and not necessarily drawn to scale. The schematic illustrations are merely examples and should not limit the scope of protection of the present invention. Furthermore, actual fabrication should involve three-dimensional spatial dimensions including length, width, and depth.

For ease of description, spatial relationship terms such as "beneath," "below," "lower," "under," "above," "upper," and the like may be used herein to describe the relationship of one element or feature shown in the accompanying drawings with another element or feature. It will be understood that these spatial relationship terms are intended to encompass other orientations of the device in use or operation, in addition to the orientation depicted in the accompanying drawings. Moreover, when a layer is referred to as being "between" two layers, the layer may be the only layer between the two layers, or one or more intervening layers may also be present. The

term "between ... and ..." as used herein includes both endpoint values.

In the context of the present application, a structure in which a first feature is described as being "on" a second feature may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which one or more additional features are formed between the first feature and the second feature, so that the first feature and the second feature may not be in direct contact.

It should be noted that the drawings provided in the embodiments are only schematic representations of the basic concept of the present invention, and thus only show components related to the present invention, rather than being drawn according to the number, shape, and size of components in actual implementation. The form, quantity, and proportion of components in actual implementation may be arbitrarily changed, and the component layout may also be more complicated.

As shown in FIG. 1 and FIG. 2, the embodiment provides a wafer transfer platform, comprising wafer cassettes 1, a process chamber 2, a temporary storage area 3, a front-end chamber 4, a front-end robot 41 located in the front-end chamber 4, and process robots 7 for transferring wafers in the process chamber 2. The front-end robot 41 and the process robots 7 are used for picking, placing, and transferring the wafers.

The wafer cassettes 1 are used for storing wafers, and a semiconductor structure is formed on each wafer. The semiconductor structure includes a dielectric layer formed on the wafer, a barrier layer on the dielectric layer, and a metal layer on the barrier layer. The semiconductor structure further includes a pattern formed on the dielectric layer, and the barrier layer and the metal layer are formed inside the pattern. During transfer, the front-end robot 41 takes out a wafer from one wafer cassette 1 and places the wafer on the temporary storage area 3; one process robot 7 moves close to the temporary storage area 3 and transfers the wafer from the temporary storage area 3 to the process chamber 2; after the wafer processing is completed, the process robot 7 takes out the processed wafer from the process chamber 2 and places the wafer back on the temporary storage area 3; the front-end robot 41 retrieves the wafer and transfers the wafer to the wafer cassette 1. In some embodiments, the wafer retrieved from the temporary storage area 3 by the front-end robot 41 may need further processing, such

as annealing, before being transferred to the wafer cassette 1.

In addition, in some embodiments, the process chamber 2 adopts a dual-layer dual-process mode. It can be understood that dual-process refers to two different treatment processes. Specifically, the process chamber 2 includes first process chambers for performing a first treatment process on the wafers and second process chambers for performing a second treatment process on the wafers, and the first treatment process is different from the second treatment process. Exemplarily, the first process chambers are electroplating chambers for electroplating the wafers, and the second process chambers are cleaning chambers for cleaning the wafers. In addition, it can be understood that the process chamber 2 includes reaction chambers arranged in a plurality of layers, and "dual-layer" means that every two process robots transfer the wafers in the reaction chambers within specific regions of every two layers, and the description of related regions will be given below in detail.

The process chamber 2 includes a plurality of reaction chambers arranged at different heights as a plurality of layers. In the embodiment shown in FIG. 1 and FIG. 2, the process chamber 2 includes two layers of reaction chambers, specifically including a first reaction chamber PM11, a second reaction chamber PM12, a third reaction chamber PM13, and a fourth reaction chamber PM14 located on the upper layer, and a fifth reaction chamber PM21, a sixth reaction chamber PM22, a seventh reaction chamber PM23, and an eighth reaction chamber PM24 located on the lower layer.

The process robots transfer the wafers between two reaction chambers of different treatment processes through a first movement or a second movement. The process robots include a first process robot and a second process robot. The first process robot is used for transferring the wafers located in a first region, and the second process robot is used for transferring the wafers located in a second region.

The plurality of reaction chambers are divided into a first region and a second region in a horizontal direction or a vertical direction. In some embodiments, the plurality of reaction chambers are divided into a first region and a second region in a vertical direction, and the process robots transfer the wafers between two reaction chambers of different treatment processes through rotational movement and/or

translational movement (first movement). The reaction chambers located in the first region include at least one first process chamber and at least one second process chamber, and the reaction chambers located in the second region include at least one first process chamber and at least one second process chamber. The first region is the upper layer, and the second region is the lower layer. Exemplarily, in one embodiment, the number of the first process chamber and the number of the second process chamber in each layer are both 1, and the first process robot and the second process robot transfer the wafers from the first process chambers to the second process chambers through rotational movement on the upper layer and the lower layer, respectively. In another embodiment, the number of at least one of the first process chamber and the second process chamber in each layer is greater than 1, the first process robot transfers the wafer on the upper layer through rotational movement and/or translational movement, and the second process robot transfers the wafer on the lower layer through rotational movement and/or translational movement. In the embodiment shown in FIG. 1, the first reaction chamber PM11 and the third reaction chamber PM13 on the upper layer are electroplating chambers, the second reaction chamber PM12 and the fourth reaction chamber PM14 are cleaning chambers, the fifth reaction chamber PM21 and the seventh reaction chamber PM23 on the lower layer are electroplating chambers, and the sixth reaction chamber PM22 and the eighth reaction chamber PM24 are cleaning chambers. It should be noted that the first reaction chamber PM11 and the second reaction chamber PM21 thereunder can be slightly offset as shown in the figure or vertically aligned. The same applies to other reaction chambers PM12 and PM22, PM13 and PM23, and PM14 and PM24.

The first process robot 71 transfers each wafer among the plurality of reaction chambers PM11, PM13, and PM12 and PM14 on the upper layer through rotational movement and/or translational movement, and the second process robot 72 transfers each wafer among the plurality of reaction chambers PM21, PM23, and PM22 and PM24 on the lower layer through rotational movement and/or translational movement, so as to transfer the wafers from the electroplating chambers to the cleaning chambers. In the embodiment of FIG. 1, the first process robot 71 transfers the wafer that has been electroplated in the first reaction chamber PM11 to one of the cleaning chambers on the upper layer, the second reaction chamber PM12 or the fourth reaction chamber PM14. If only one of the two cleaning chambers is idle, the wafer is transferred to the

idle reaction chamber by the first process robot 71; if both the cleaning chambers are idle, the wafer is transferred to the cleaning chamber closest to the first reaction chamber PM11 by the first process robot 71. As shown in the example in FIG. 1, the first process robot 71 moves to a position above the first process robot 72 by translational movement, takes out the wafer from the first reaction chamber PM11, then returns to the position in FIG. 1, and transfers the wafer to the second reaction chamber PM12, or further transfers the wafer to the fourth reaction chamber PM14 by rotational movement. In this embodiment, the movement manner of the second process robot 72 is the same as the movement manner of the first process robot 71, which will not be repeated herein. It can be understood that the positions of the electroplating chambers and the cleaning chambers on the upper layer in FIG. 1 can be interchanged arbitrarily, and the positions of the electroplating chambers and the cleaning chambers on the lower layer can also be interchanged arbitrarily. According to the distribution of the electroplating chambers and the cleaning chambers in the first region and the second region, the movement manners of the first process robot and the second process robot change accordingly. The present invention does not limit the movement manners of the first process robot and the second process robot, and any movement manner that transfers the wafers from the first process chambers to the second process chambers falls within the protection scope of the present invention. Exemplarily, in FIG. 1, the first reaction chamber PM11 and the second reaction chamber PM12 on the upper layer are electroplating chambers, and the third reaction chamber PM13 and the fourth reaction chamber PM14 are cleaning chambers. The first process robot 71 moves to a position above the second process robot 72 by translational movement, then transfers the wafer from the first reaction chamber PM11 to the third reaction chamber PM13 by rotational movement, or can also transfer the wafer from the first reaction chamber PM11 to the fourth reaction chamber PM14 by rotational and translational movement.

In other embodiments, a plurality of reaction chambers are divided into a first region and a second region in a horizontal direction, and the process robots transfer wafers between two reaction chambers of different treatment processes through vertical movement and/or translational movement (second movement). The reaction chambers located in the first region include at least one first process chamber and at least one second process chamber, and the reaction chambers located in the second region include at least one first process chamber and at least one second process

chamber. The first region and the second region are opposite, such as front-back opposed or left-right opposed. Exemplarily, in one embodiment, the number of the first process chamber and the number of the second process chamber in each region are both 1, and the first process chamber and the second process chamber are respectively arranged in two layers, one above the other. Herein, the first process robot transfers each wafer in the first region from the first process chamber to the second process chamber by vertical movement, and the second process robot transfers each wafer in the second region from the first process chamber to the second process chamber by vertical movement. In another embodiment, the number of at least one of the first process chamber and the second process chamber in each region is greater than 1, and the process robots transfer each wafer in the first region and the second region by vertical movement and/or translational movement, transferring the wafer from the first process chambers to the second process chambers. In the embodiment shown in FIG. 2, the first reaction chamber PM11, the second reaction chamber PM12, the third reaction chamber PM13, and the fourth reaction chamber PM14 are electroplating chambers, and the fifth reaction chamber PM21, the sixth reaction chamber PM22, the seventh reaction chamber PM23, and the eighth reaction chamber PM24 are cleaning chambers. It should be noted that the first reaction chamber PM11 and the second reaction chamber PM21 thereunder can be slightly offset as shown in the figure or vertically aligned. The same applies to other reaction chambers PM12 and PM22, PM13 and PM23, and PM14 and PM24.

The first process robot 71 transfers each wafer among the reaction chambers on the left side (first region) of the process chamber 2 by vertical movement and/or translational movement, and the second process robot 72 transfers each wafer among the reaction chambers on the right side (second region) of the process chamber 2 by vertical movement and/or translational movement. As shown in the embodiment in FIG. 2, the first process robot 71 transfers the wafer that has been electroplated in the first reaction chamber PM11 to one of the cleaning chambers on the left side, the fifth reaction chamber PM21 or the sixth reaction chamber PM22. If only one of the two cleaning chambers is idle, the wafer is transferred to that idle reaction chamber by the first process robot 71; if both the cleaning chambers are idle, the wafer is transferred to the cleaning chamber closest to the first reaction chamber PM11 by the first process robot 71. As shown in the example in FIG. 2, the first process robot 71 transfers the

wafer from the first reaction chamber PM11 to the fifth reaction chamber PM21 by vertical movement, or can also transfer the wafer from the first reaction chamber PM11 to the sixth reaction chamber PM22 by vertical movement and translational movement. In this embodiment, the movement manner of the second process robot 72 is the same as the movement manner of the first process robot 71, which will not be repeated herein. It can be understood that the upper and lower positions of the electroplating chambers and the cleaning chambers on the left side in FIG. 2 can be interchanged arbitrarily, and the upper and lower positions of the electroplating chambers and the cleaning chambers on the right side can also be interchanged arbitrarily. According to the distribution of the electroplating chambers and the cleaning chambers in the first region and the second region, the movement manners of the first process robot and the second process robot change accordingly. The present invention does not limit the movement manners of the first process robot and the second process robot, and any movement manner that transfers the wafers from the first process chambers to the second process chambers falls within the protection scope of the present invention. Exemplarily, in FIG. 2, the first reaction chamber PM11 and the fifth reaction chamber PM21 on the left side are electroplating chambers, and the second reaction chamber PM12 and the sixth reaction chamber PM22 are cleaning chambers. The first process robot 71 transfers the wafer from the first reaction chamber PM11 to the second reaction chamber PM12 by translational movement, or can also transfer the wafer from the first reaction chamber PM11 to the sixth reaction chamber PM22 by vertical movement and translational movement. By transferring wafers from the first process chambers to the second process chambers in a partitioned manner, the first process robot and the second process robot overcome the defect caused by waiting for the process robots to transfer wafers during wafer processing, greatly shortening the response time of the process robots, and achieving high throughput.

In addition, generally, the electroplating time of a wafer is close to or longer than the cleaning time. If the electroplating time is longer than the cleaning time, the number of electroplating chambers can be set to be greater than the number of cleaning chambers, and a plurality of electroplating chambers can share one cleaning chamber. Since the electroplating time is longer as the film thickness increases, for example, when the film thickness increases, the electroplating time is close to twice the cleaning time, and the number of electroplating chambers can be selected to be twice the number

of cleaning chambers. If the electroplating time is close to the cleaning time, the number of electroplating chambers can be set to be equal to the number of cleaning chambers. Preferably, the number of electroplating chambers (first process chambers) and the number of cleaning chambers (second process chambers) in each region are the same, preventing reaction chambers from being idle after the completion of processing in the electroplating chambers (the first process chambers) or the cleaning chambers (the second process chambers). The semiconductor apparatus is suitable for electroplating processes of various film thicknesses and has broader applicability.

In summary, from another perspective, the wafer transfer method comprises the following steps:

S1. transferring wafers from a wafer cassette to a temporary storage area by a front-end robot;

S2. transferring the wafers from the temporary storage area to first process chambers of a process chamber for a first treatment process by a first process robot and a second process robot, respectively;

S3. transferring the wafer in a first region by the first process robot through a first movement or a second movement, and transferring the wafer in a second region by the second process robot through a first movement or a second movement, so as to transfer the wafers from the first process chambers among a plurality of reaction chambers to second process chambers for a second treatment process;

S4. transferring the wafers from the second process chambers to the temporary storage area;

S5. transferring the wafers from the temporary storage area back to the wafer cassette by the front-end robot.

Wherein, in step S3, the plurality of reaction chambers are arranged in a dual-layer dual-process manner, and the first process robot and the second process robot move in the plurality of reaction chambers in the first region and the second region respectively to transfer the wafers in a partitioned manner. In one embodiment, the first process robot and the second process robot can respectively perform a first movement,

and the first movement is a rotational movement and/or a translational movement. The plurality of reaction chambers are divided into regions according to an upper layer and a lower layer, wherein the reaction chambers located on the upper layer include at least one first process chamber and at least one second process chamber, and the reaction chambers located on the lower layer include at least one first process chamber and at least one second process chamber. Herein, the first process robot and the second process robot respectively perform the first movement in the plurality of reaction chambers on the upper layer (first region) and the lower layer (second region) to transfer the wafers in a partitioned manner. In another embodiment, the first process robot and the second process robot can perform a second movement in the plurality of reaction chambers, and the second movement is a vertical movement and/or a translational movement. The plurality of reaction chambers are divided into regions according to a first position and a second position, and the first position and the second position are opposite, for example, the first position and the second position are front-back opposed or left-right opposed. Wherein, the reaction chambers located in the first position (first region) include at least one first process chamber and at least one second process chamber, and the reaction chambers located in the second position (second region) include at least one first process chamber and at least one second process chamber. Herein, the first process robot and the second process robot respectively perform the second movement in the plurality of reaction chambers located in the first position (first region) and the second position (second region) to transfer the wafers in a partitioned manner.

In addition, in step S3, when the process robots transfer the wafers from current first process chambers to idle second process chambers in corresponding regions, if more than one idle second process chamber is present in corresponding regions, the idle second process chambers closest to the current first process chambers are selected, further simplifying the movement of the process robots.

In step S5, transferring the wafers from the temporary storage area back to the wafer cassette specifically includes: the front-end robot transferring the wafers from the temporary storage area to an annealing chamber for annealing, and then transferring the wafers back to the wafer cassette.

More details of this method embodiment can be referred to the previous

description of the wafer transfer platform, which will not be expanded herein.

In the present invention, the first process robot and the second process robot transfer the wafers from the first process chambers to the second process chambers in a partitioned manner, simplifying the movement process, overcoming the defect caused by waiting for the process robots to transfer the wafers during wafer processing, greatly shortening the response time of the process robots, and achieving high throughput.

The embodiments described above are only illustrative of the principle and effect of the present invention, and are not intended to limit the present invention. Any person skilled in the art can make modifications or changes to the embodiments described above without departing from the spirit and scope of the present invention. Therefore, all equivalent modifications or changes made by those of ordinary skill in the art without departing from the spirit and technical concept disclosed in the present invention shall still be covered by the claims of the present invention.

What is claimed is:

1. A wafer transfer platform, comprising:

a first process robot and a second process robot, for picking, placing, and transferring wafers;

a process chamber, including a plurality of reaction chambers arranged at different heights as a first layer and a second layer, the plurality of reaction chambers including first process chambers for performing a first treatment process on the wafers and second process chambers for performing a second treatment process on the wafers, and the plurality of reaction chambers being divided into a first region and a second region in a horizontal direction or a vertical direction;

wherein, the first process robot and the second process robot are respectively configured to transfer the wafers in the first region and the second region to transfer the wafers from the first process chambers to the second process chambers.

2. The wafer transfer platform according to claim 1, wherein the reaction chambers located in the first region include at least one first process chamber and at least one second process chamber, and the reaction chambers located in the second region include at least one first process chamber and at least one second process chamber.

3. The wafer transfer platform according to claim 1, wherein the number of at least one of the first process chamber and the second process chamber in each region is greater than 1.

4. The wafer transfer platform according to claim 1, wherein the number of the first process chambers and the number of the second process chambers in each region are the same.

5. The wafer transfer platform according to claim 1, wherein the first process chambers are electroplating chambers, and the second process chambers are cleaning chambers.

6. The wafer transfer platform according to claim 1, wherein the first region and the second region are formed by dividing the plurality of reaction chambers in a horizontal direction, and the first process robot and the second process robot transfer the wafers by rotational and/or translational movement.

7. The wafer transfer platform according to claim 1, wherein the first region and the second region are formed by dividing the plurality of reaction chambers in a vertical direction, and the first process robot and the second process robot transfer the wafers by vertical and/or translational movement.

8. The wafer transfer platform according to claim 1, wherein the first process robot and the second process robot are further configured to transfer the wafers from current first process chambers to idle second process chambers in corresponding regions.

9. The wafer transfer platform according to claim 8, wherein the first process robot and the second process robot are configured to transfer the wafers from current first process chambers to the second process chambers closest to the current first process chambers.

10. A wafer transfer method, comprising the following steps:

transferring wafers from a wafer cassette to a temporary storage area by a front-end robot;

transferring the wafers from the temporary storage area to respective first process chambers among a plurality of reaction chambers in a first region and a second region of a process chamber by a first process robot and a second process robot, respectively, for performing a first treatment process;

transferring the wafers in corresponding regions by the first process robot and the second process robot, respectively, to transfer the wafers from the first process chambers among the plurality of reaction chambers to second process chambers for performing a second treatment process;

transferring the wafers from the second process chambers to the temporary

storage area;

transferring the wafers from the temporary storage area back to the wafer cassette by the front-end robot.

11. The wafer transfer method according to claim 10, wherein the first region and the second region are formed by dividing the plurality of reaction chambers in a horizontal direction, and the first process robot and the second process robot transfer the wafers by rotational and/or translational movement.

12. The wafer transfer method according to claim 11, wherein the first region and the second region are formed by dividing the plurality of reaction chambers in a vertical direction, and the first process robot and the second process robot transfer the wafers by vertical and/or translational movement.

13. The wafer transfer method according to claim 10, wherein in the step of transferring the wafers in corresponding regions by the first process robot and the second process robot, respectively, the first process robot and the second process robot transfer the wafers from current first process chambers to idle second process chambers in corresponding regions.

14. The wafer transfer method according to claim 13, wherein in the step of transferring the wafers in corresponding regions by the first process robot and the second process robot, respectively, the first process robot and the second process robot transfer the wafers from current first process chambers to the second process chambers closest to the current first process chambers.