SUBSTRATE PROCESSING DEVICE, SUBSTRATE PROCESSING METHOD, AND BUFFER MODULE

FIELD OF THE INVENTION

The present application relates to the technical field of semiconductor equipment, and specifically relates to a substrate processing device, a substrate processing method, and a buffer module.

BACKGROUND

With the rapid development of advanced technologies such as mobile phones, 5G communication, the Internet of Things, artificial intelligence, and edge computer, higher requirements are put forward for the operating speed and performance of integrated circuits. At present, the chips are designed to have an increasingly smaller feature size, and the aspect ratio is getting higher and higher, which brings more severe challenges to multiple processes. Taking dynamic random access memory (DRAM) as an example, as key technology nodes of DRAM continue to evolve and feature sizes gradually shrink to 17/19 nm and beyond, the aspect ratios of shallow trench isolation (STI) and storage capacitor (SN) modules become increasingly higher. Such patterned structures with ultra-high aspect ratios impose stricter requirements on cleaning and drying processes, and the main challenges are as follows: 1) Chemicals have difficulty penetrating into the deep trenches; 2) The surface tension of liquid easily causes adhesion and collapse of structures with high aspect ratios during cleaning and drying processes.

To solve the above problems, supercritical fluid drying technology with zero surface tension has emerged as required. Especially at the 17/19 nm technology node, supercritical fluid drying technology has become an indispensable technology. As a special fourth state of matter distinct from solid, liquid, and gas, supercritical fluid has properties between liquid and gas, featuring high density, easy diffusion, and zero surface tension, so the supercritical fluid is particularly suitable for cleaning and drying structures with high aspect ratios. However, process conditions of the supercritical fluid require high temperature and high pressure, which impose high requirements on hardware and strict requirements on process parameters. The flow field is a very critical

factor, and strong flow fields (such as excessively high flow velocity) may impact the patterned structures on the substrate surface and cause adhesion of patterned structures during drying. The flow field on the substrate surface inside an existing drying chamber is difficult to adjust.

SUMMARY

The technical problem to be solved by the present invention is to overcome the defect that the flow field inside the drying chamber is difficult to adjust in the prior art. The present invention provides a substrate processing device, a substrate processing method, and a buffer module.

The present invention solves the above technical problem through the following technical solutions.

The present invention provides a substrate processing device, comprising:

a drying module, including a drying chamber;

a carrier member, detachably arranged relative to the drying chamber, wherein the carrier member includes a carrying portion and a blocking portion, the carrying portion is configured to carry a substrate, the blocking portion is disposed on the outer periphery of the carrying portion, and the blocking portion is configured such that when the carrying portion carries the substrate, the height of the blocking portion is not lower than the height of the substrate.

The present invention provides a substrate processing method, wherein a carrier member for placing a substrate is provided. The carrier member includes a carrying portion and a blocking portion, the carrying portion is configured to carry the substrate, the blocking portion is arranged surrounding the carrying portion, and the blocking portion is configured such that when the carrying portion carries the substrate, the height of the blocking portion is not lower than the height of the substrate. The method comprises the following steps:

placing the cleaned substrate onto the carrier member;

transferring the carrier member together with the substrate into a drying chamber to perform drying treatment.

The present invention provides a buffer module configured to carry a carrier member, wherein the carrier member includes a carrying portion and a blocking portion, the carrying portion is configured to carry a substrate, the blocking portion is arranged surrounding the carrying portion, and the blocking portion is configured such that when the carrying portion carries the substrate, the height of the blocking portion is not lower than the height of the substrate. The buffer module includes:

a base, configured to carry the carrier member;

a lifting support post, disposed on the base and capable of moving vertically, wherein the carrying portion is provided with an opening matched to the lifting support post, the lifting support post can penetrate through the opening to carry the substrate, so as to place the substrate onto the carrying portion or lift the substrate off the carrying portion.

The positive and progressive effects of the present invention are as follows:

1. The substrate is placed on the carrying portion, and the blocking portion is arranged surrounding the carrying portion. The carrier member is detachably arranged relative to the drying chamber. Compared to an integrated design of the carrier member and the drying chamber, the carrier member can be more easily taken out from the drying chamber, and carrier members of different specifications can be conveniently replaced outside the drying chamber, so the height and shape of the blocking portion can be adjusted more easily. When supercritical fluid drying technology is used for drying, the blocking portion can adjust the flow field acting on the substrate. For different patterned structures on the substrate, the height and shape of the blocking portion can be adjusted more conveniently. For example, for patterned structures with ultra-high aspect ratios which require an extremely gentle flow field, the height of the blocking portion can be increased. The fluid is blocked by the blocking portion, so the flow velocity on the substrate surface decreases, and a flow field better matched to the patterned structures can be obtained. This arrangement reduces the occurrence of pattern collapse during drying and helps improve the product yield.

2. The lifting support post arranged in the buffer module enables more convenient placement of the substrate. When the carrier member receives the substrate, the lifting support post can ascend vertically, such that the upper end surface of the lifting support post is higher than the blocking portion, so the blocking portion will not interfere with a robot. The robot can place the substrate onto the lifting support post, and then the lifting support post descends vertically to place the substrate onto the carrying portion.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and performance of the present application are further illustrated by the following embodiments and accompanying drawings of the embodiments.

FIG. 1 is a schematic structural diagram of the drying module according to Embodiment 1 of the present invention;

FIG. 2 is a schematic module diagram of the substrate processing device according to Embodiment 1 of the present invention;

FIG. 3 is a schematic structural diagram of the buffer module according to Embodiment 1 of the present invention;

FIG. 4 is a schematic structural diagram of the carrier member according to Embodiment 1 of the present invention;

FIG. 5 is a schematic structural diagram of the buffer module in a first state according to Embodiment 1 of the present invention;

FIG. 6 is a schematic structural diagram of the buffer module in a second state according to Embodiment 1 of the present invention;

FIG. 7 is a schematic flow diagram of the substrate processing method according to Embodiment 2 of the present invention.

PREFERRED EMBODIMENTS OF THE APPLICATION

The present invention will be further described below through embodiments, but

the present invention is not limited to the scope of the embodiments.

Embodiment 1

As shown in FIG. 1, the present embodiment provides a substrate processing device comprising a drying module 100 and a carrier member 210. The drying module 100 includes a drying chamber 110 configured to perform drying treatment on a substrate W. The carrier member 210 is detachably arranged inside the drying chamber 110. The carrier member 210 includes a carrying portion 211 and a blocking portion 212. The carrying portion 211 is configured to carry the substrate W. The blocking portion 212 is disposed on the outer periphery of the carrying portion 211, and the blocking portion 212 is configured such that when the carrying portion 211 carries the substrate W, the height of the blocking portion 212 is not lower than the height of the substrate W.

The substrate W is placed on the carrying portion 211, and the blocking portion 212 is arranged surrounding the carrying portion 211. Since the carrier member 210 is detachably arranged relative to the drying chamber 110, compared to an integrated design of the carrier member 210 and the drying chamber 110, the carrier member 210 can be more easily taken out from the drying chamber 110, and carrier members of different specifications can be conveniently replaced outside the drying chamber, so the height and shape of the blocking portion 212 can be adjusted more easily. For different patterned structures on the substrate W, the height and shape of the blocking portion 212 can be adjusted more conveniently. For example, for patterned structures with ultra-high aspect ratios which require an extremely gentle flow field, the height of the blocking portion 212 can be increased to obtain a flow field better matched to the patterned structures, thereby reducing the occurrence of pattern collapse during drying and helping improve the product yield. In addition, an opening may be arranged on the blocking portion 212 to optimize the flow field.

In the present embodiment, to further facilitate adjustment of the blocking portion 212, the blocking portion 212 is detachably mounted on the carrying portion 211.

In the present embodiment, the drying module 100 uses supercritical fluid to dry the substrate W. The drying module 100 further includes third support posts 120

disposed at the bottom of the drying chamber 110 and configured to carry the carrier member 210. The drying module 100 further includes a first fluid supply pipe 130, a second fluid supply pipe 150, and a fluid discharge pipe 160. The first fluid supply pipe 130 is configured to supplement organic solvent into the drying chamber 110, such as ethylene glycol, methanol, ethanol, n-propyl alcohol, isopropyl alcohol (IPA), and other alcohols, tetrahydrofuran, dimethyl ether, etc. The supplementary amount of the organic solvent can be determined according to the total weight of the carrier member 210 and the substrate W. To mitigate the impact of the supplied organic solvent on the substrate W, a spray head 140 is arranged at a supply port of the first fluid supply pipe 130. The spray head 140 is located directly above the substrate W, and the projection of the spray head 140 toward the substrate W covers the outer edge of the substrate W. The spray head 140 sprays the organic solvent toward the surface of the substrate W in a shower manner, which can effectively avoid damage to the patterns on the substrate W. The second fluid supply pipe 150 is configured to supply supercritical fluid, such as supercritical carbon dioxide ($SCCO_2$), into the drying chamber 110 after the substrate W is immersed in the organic solvent. The fluid discharge pipe 160 is configured to discharge the organic solvent and supercritical fluid from the drying chamber 110.

The drying chamber 110 is provided with doors 1101. When the doors 1101 are opened, the carrier member 210 together with the substrate W is transferred onto the third support posts 120 inside the drying chamber 110. After the carrier member 210 and the substrate W are transferred into the drying chamber 110, the doors 1101 are closed to seal the drying chamber 110, so as to form a closed space inside the drying chamber 110 for processing the substrate W. After the drying treatment of the substrate W is completed, the doors 1101 are opened to move the carrier member 210 together with the substrate W out of the drying chamber 110.

Further, the carrier member 210 further includes first support posts 213 disposed on the carrying portion 211, and the first support posts 213 are configured to carry the substrate W. The first support posts 213 are in direct contact with the substrate W, so the first support posts 213 are made of a special material with high friction and capable of withstanding high temperature, high pressure, and supercritical fluid, such as Polytetrafluoroethylene (PTFE).

In other embodiments, the first support posts 213 may be omitted, and the substrate may be directly placed on the carrying portion 211.

As shown in FIGS. 2 and 3, in the present embodiment, the substrate processing device further comprises a buffer module 200 and a transfer module 300. The buffer module 200 is disposed outside the drying chamber 110. The buffer module 200 further includes a base 220 and second support posts 230 disposed on the base 220, and the second support posts 230 are configured to carry the carrier member 210. When the carrier member 210 is placed on the second support posts 230, a certain gap is formed between the carrier member 210 and the base 220. This gap facilitates the transfer module 300 to transfer the carrier member 210. For example, if the transfer module 300 uses a robot to transfer the carrier member 210, the gap can reserve a pick-and-place space for the robot. The transfer module 300 is configured to transfer the carrier member 210 and the substrate placed on the carrying portion 211 between the buffer module 200 and the drying chamber 110. When supercritical fluid is used to dry the substrate, the transfer module 300 transfers the carrier member 210 together with the substrate into the drying chamber 110, and the blocking portion 212 can adjust the flow field acting on the substrate surface.

In other embodiments, the buffer module 200 may be omitted, and the carrier member 210 is only taken out from the drying chamber 110 when the adjustment of the blocking portion 212 is required.

In the present embodiment, the substrate processing device further comprises a cleaning module 400 configured to clean the substrate, and the transfer module 300 is further configured to transfer the substrate cleaned by the cleaning module 400 to the buffer module 200.

In other embodiments, the second support posts 230 may be omitted, and the carrier member 210 is directly placed on the base 220. Grooves may be pre-formed on the base 220 to reserve pick-and-place space for the robot.

Further, the buffer module 200 further includes a weight measurement module (not shown in the figures). The weight measurement module is disposed on the second support posts 230 and configured to measure the weight of the carrier member 210 and

the substrate. In some embodiments where the second support posts 230 are omitted, the weight measurement module may be disposed between the carrier member 210 and the base 220.

As shown in FIGS. 3 and 4, in the present embodiment, since the height of the blocking portion 212 is not lower than the height of the substrate, the robot is prone to interfere with the blocking portion 212 when the robot picks and places the substrate due to the influence of the blocking portion 212. Therefore, to prevent the blocking portion 212 from affecting the robot during substrate pick-and-place operations, the buffer module 200 further includes lifting support posts 240 disposed on the base 220. The carrying portion 211 is provided with openings 2111 matched to the lifting support posts 240. The lifting support posts 240 are configured to penetrate through the openings 2111 and move vertically. When the lifting support posts 240 descend, the lifting support posts 240 are configured to place the substrate carried on the lifting support posts 240 onto the first support posts 213 of the carrying portion 211; when the lifting support posts 240 ascend, the lifting support posts 240 are configured to lift the substrate off the first support posts 213 on the carrying portion 211.

As shown in FIG. 5, when the carrier member 210 receives the substrate W, the upper end surfaces of the lifting support posts 240 are higher than the upper end surface of the blocking portion 212, so the blocking portion 212 cannot interfere with the robot, and the robot can place the substrate W onto the lifting support posts 240. Subsequently, the lifting support posts 240 descend to place the substrate W onto the first support posts 213, and the state of the buffer module 200 at this time is shown in FIG. 6.

In other embodiments, the lifting support posts 240 may be omitted, and the structure of the robot may be improved, for example, by adding a vacuum adsorption device on the robot to pick up the substrate, so that the robot can pick and place the substrate while avoiding the blocking portion 212.

Embodiment 2

As shown in FIG. 7, the present embodiment provides a substrate processing method using the carrier member described in Embodiment 1, comprising the following steps:

S10: placing the cleaned substrate onto the carrier member;

S20: transferring the carrier member together with the substrate into a drying chamber to perform drying treatment.

By using the substrate processing method of the present embodiment, the height and shape of the blocking portion on the carrier member can be adjusted more conveniently for different patterned structures on the substrate. For example, for patterned structures with ultra-high aspect ratios which require an extremely gentle flow field, the height of the blocking portion can be increased to obtain a flow field better matched to the patterned structures, thereby reducing the occurrence of pattern collapse during drying and helping improve the product yield.

Although specific embodiments of the present invention have been described above, those skilled in the art should understand that the above embodiments are merely illustrative examples, and the protection scope of the present invention is defined by the appended claims. Those skilled in the art may make various changes and modifications to the above embodiments without departing from the principle and essence of the present invention, and all such changes and modifications shall fall within the protection scope of the present invention.

What is claimed is:

1. A substrate processing device, comprising:

a drying module, including a drying chamber;

a carrier member, detachably arranged relative to the drying chamber, wherein the carrier member includes a carrying portion and a blocking portion, the carrying portion is configured to carry a substrate, the blocking portion is disposed on the outer periphery of the carrying portion, and the blocking portion is configured such that when the carrying portion carries the substrate, the height of the blocking portion is not lower than the height of the substrate.

2. The substrate processing device according to claim 1, wherein the carrier member further includes a first support post disposed on the carrying portion, and the first support post is configured to carry the substrate.

3. The substrate processing device according to claim 1, further comprising:

a buffer module, disposed outside the drying chamber, including a base configured to carry the carrier member;

a transfer module, configured to transfer the carrier member and the substrate placed on the carrying portion between the buffer module and the drying chamber.

4. The substrate processing device according to claim 3, wherein the buffer module further includes a second support post disposed on the base, and the second support post is configured to carry the carrier member.

5. The substrate processing device according to claim 3, wherein the buffer module further includes a weight measurement module configured to measure the weight of the carrier member and the substrate.

6. The substrate processing device according to claim 3, wherein the buffer module further includes a lifting support post disposed on the base, the carrying portion is provided with an opening matched to the lifting support post, the lifting support post

is configured to penetrate through the opening and move vertically, when the lifting support post descends, the lifting support post is configured to place the substrate carried on the lifting support post onto the carrying portion; when the lifting support post ascends, the lifting support post is configured to lift the substrate off the carrying portion.

7. The substrate processing device according to claim 1, wherein the drying module further includes a third support post disposed at the bottom of the drying chamber, and the third support post is configured to carry the carrier member.

8. The substrate processing device according to claim 1, wherein the drying module is configured to dry the substrate by using supercritical fluid.

9. The substrate processing device according to claim 3, wherein the substrate processing device further comprises a cleaning module configured to clean the substrate, and the transfer module is further configured to transfer the substrate cleaned by the cleaning module onto the carrier member.

10. The substrate processing device according to claim 1, wherein the blocking portion is detachably mounted on the carrying portion.

11. A substrate processing method, comprising:

providing a carrier member for placing a substrate, wherein the carrier member includes a carrying portion and a blocking portion, the carrying portion is configured to carry the substrate, the blocking portion is arranged surrounding the carrying portion, and the blocking portion is configured such that when the carrying portion carries the substrate, the height of the blocking portion is not lower than the height of the substrate;

placing the cleaned substrate onto the carrier member;

transferring the carrier member together with the substrate into a drying chamber to perform drying treatment.

12. A buffer module, comprising:

a base, configured to carry a carrier member, wherein the carrier member includes a carrying portion and a blocking portion, the carrying portion is configured to carry a substrate, the blocking portion is arranged surrounding the carrying portion, and the blocking portion is configured such that when the carrying portion carries the substrate, the height of the blocking portion is not lower than the height of the substrate;

a lifting support post, disposed on the base, wherein the carrying portion is provided with an opening matched to the lifting support post, the lifting support post is configured to penetrate through the opening and move vertically, when the lifting support post descends, the lifting support post is configured to place the substrate carried on the lifting support post onto the carrying portion; when the lifting support post ascends, the lifting support post is configured to lift the substrate off the carrying portion.

13. The buffer module according to claim 12, wherein the buffer module further includes a second support post disposed on the base, and the second support post is configured to carry the carrier member.