Description

Vacuum suction heater

Technical Field

The present application relates to a device for heating a wafer in a semiconductor processing chamber, in particular to a vacuum suction heater. The present application also relates to a vacuum suction system that can be used in conjunction with a vacuum suction heater, as well as a suction method using the vacuum suction system to suck the wafer.

Background

A wafer or substrate board is used as a substrate for fabricating a semiconductor device. In order to fabricate the semiconductor device (such as integrated circuit, semiconductor light emitting device, etc.), it needs to place the wafer or substrate board in a semiconductor processing chamber (also known as a reaction chamber) for heating and deposition treatment (such as chemical vapor deposition (CVD), plasma enhanced chemical vapor deposition (PECVD), etc.), for depositing a thin film on the surface of the wafer or substrate board. During the processing, the wafer can be fixed on a heater inside the processing chamber by vacuum suction and other methods.

However, the existing vacuum suction heaters, vacuum suction systems, and their suction methods have many drawbacks.

For example, the bearing surface of the heater is in a face contact with the wafer, which can easily lead to uneven contact. For example, due to the surface roughness and machining errors of the bearing surface and the wafer itself, when the wafer is placed on the bearing surface, these two may not fully and uniformly adhere. It might be suspended for some positions, or there might be uneven gaps in different positions.

In this case, on one hand, it may lead to uneven heating at various positions of the wafer during heating by the heater, resulting in poor heating effect and even affecting the qualification rate of the wafer. On the other hand, it may lead to

insufficient vacuum suction force on the wafer during operation, resulting in poor suction effect. Even the wafer may move on the bearing surface, especially in processing chambers with high gas flow rate and pressure, where the possibility of wafer movement is greater.

In addition, some vacuum suction structures (such as passing hole on the heating plate, suction pipeline inside the heating plate, etc.) on the vacuum suction heater are difficult to process due to their small size and deep depth, making them processing difficult and costly.

In addition, the existing vacuum suction systems generally extract gas (air) from the suction pipeline inside the heater only by a vacuum pump, thereby controlling the pressure difference between the back side of the wafer (i.e. the surface in contact with the wafer bearing surface of the heater) and the front side. Therefore, during the sucking and releasing process of the wafer, the pressure in the suction pipeline inside the heater can only be controlled by operating the vacuum pump (or valve on the vacuum pump pipeline), thereby controlling the suction force on the wafer by controlling the pressure difference between the back side and front side of the wafer. However, this method is very inconvenient (or even impossible) to adjust the suction force on the wafer as needed. Moreover, during the process of releasing the wafer, a pressure on the back of the wafer can be roughly the same as the front pressure, only by closing the vacuum pump (or the valve on the vacuum pump pipeline) and allowing gas in the reaction chamber to automatically flow into the suction pipeline inside the heater, straight to the back of the wafer, so as to release the wafer. This entire process takes a long time, thereby reducing work efficiency.

Therefore, it is necessary to improve the vacuum suction heaters, vacuum suction systems and wafer suction methods using vacuum suction systems in existing technologies, so as to solve the above technical problems.

Summary

The purpose of present application is to solve at least one of the problems in the existing technology above, and to provide an improved vacuum suction heater. This heater can create uniform point contact between a bearing surface and a wafer placed

thereon, thus effectively sucking the wafer during operation, preventing wafer from moving on the bearing surface of the heater (even in reaction chambers with high gas flow rate and pressure), and ensuring that the entire wafer is uniformly heated, thereby improving product quality of the wafer.

At the same time, the present application also provides a vacuum suction system. When using the vacuum suction system to suck wafers, the air pressure in the suction pipeline inside the heater can be conveniently adjusted during the sucking and releasing process of the wafer, thereby adjusting the pressure difference between the back side and front side of the wafer (i.e. adjusting the magnitude of the suction force). Therefore, not only the various suction needs of the wafer (for example, some processing technology of the wafer require larger suction force, while others require smaller suction force) can be met, but also gas can be introduced to quickly increase the pressure on the back side of the wafer to equal to or even greater than the pressure on the front side thereof during the releasing process of the wafer, thus eliminating the suction force in a short period of time and releasing the wafer, which is beneficial for improving work efficiency.

The present application provides a vacuum suction heater, comprising: a heating plate, wherein the heating plate comprises a generally disc-shaped main body, the main body has an upper surface for bearing a wafer, and further comprises: a plurality of grooves extending downwards from the upper surface, wherein at least a portion of the plurality of grooves are fluid connected to each other; one or more passing holes, which are fluid connected to at least one of the plurality of grooves; and a plurality of protrusions situated on the upper surface, which are used to support the wafer.

In some embodiments of the present application, each of the protrusions is generally circular, a diameter thereof is 1.0-3.0mm, and a height is less than or equal to 0.2mm; a distance between two adjacent protrusions is 3-20mm.

In some embodiments of the present application, the plurality of grooves comprise a plurality of annular grooves arranged in concentric circumferences and a radial groove that fluid connect the annular grooves, widths of the annular groove and the radial groove are both 0.5-1.5mm and depths are less than or equal to 1.0mm; a

distance between two adjacent annular grooves is 10-50mm.

In some embodiments of the present application, the diameter of each of the protrusions is 1.5-2.5mm, and the height is less than or equal to 0.1mm; the distance between two adjacent protrusions is 5-15mm; the widths of the annular groove and the radial groove are both 0.5-1.0mm, and the depths are less than or equal to 0.5mm; the distance between two adjacent annular grooves is 15-50mm.

In some embodiments of the present application, the widths of the annular groove and the radial groove are both 1.0mm, the depths are 0.5mm; and the distance between two adjacent annular grooves is 21.5mm. In one embodiment, the diameter of each of the protrusions is 2.0mm and the height is 0.1mm; and the plurality of protrusions are distributed along a circumference, thereby forming a plurality of concentric circumferences, and the distances between two adjacent protrusions situated on the same circumference and between two adjacent circumferences are 7mm. In another embodiment, the diameter of each of the protrusions is 2.0mm and the height is 0.1mm; and the plurality of protrusions are distributed in a triangular shape, and the distance between two adjacent protrusions is 10mm or 5mm.

In some other embodiments of the present application, the widths of the annular groove and the radial groove are both 1.0mm, the depths are 0.5mm; and the distance between two adjacent annular grooves is 43mm. In an embodiment, the diameter of each of the protrusions is 2.0mm and the height is 0.1mm; and the plurality of protrusions are distributed along a circumference, thereby forming a plurality of concentric circumferences, and the distances between two adjacent protrusions situated on the same circumference and between two adjacent circumferences are 7mm or 15mm. In another embodiment, the diameter of each of the protrusion is 2.0mm and the height is 0.1mm; and the plurality of protrusions are distributed in a triangular shape, and the distance between two adjacent protrusions is 10mm or 5mm.

In some embodiments of the present application, the plurality of grooves are generally uniformly distributed on the upper surface.

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In some embodiments of the present application, the plurality of grooves and the

plurality of protrusions are both generally uniformly distributed on the upper surface.

In some embodiments of the present application, the heating plate further comprises a supporting shaft situated below the main body, and the supporting shaft is a hollow structure and integrated with the main body.

In some embodiments of the present application, the vacuum suction heater comprises a plurality of sequentially stacked quartz blocks and/or polyether ether ketone blocks situated inside the supporting shaft.

In some embodiments, the vacuum suction heater further comprises a heating element situated inside the main body and a heating rod electrically connected to the heating element, the heating rod is situated inside the supporting shaft, goes through the quartz blocks and/or the polyether ether ketone blocks, and can be electrically connected to an external power source.

In some embodiments, the vacuum suction heater further comprises a through hole, which goes through the quartz blocks and/or the polyether ether ketone blocks, fluid connects the passing hole, and can be fluid coupled to a vacuum pump during operation. In some embodiments, a diameter of the through hole is 2-3mm; a depth of the through hole in each of the quartz blocks or the polyether ether ketone blocks is 20-25mm.

In some embodiments, the main body comprises only one passing hole, the passing hole is situated in one of the grooves, and a diameter thereof is greater than the width of the groove. In some embodiments, the diameter of the passing hole is 0.8-1.8mm.

In some embodiments, the vacuum suction heater further comprises a cooling block situated outside the supporting shaft and at least partially surrounding the supporting shaft.

In some embodiments, the vacuum suction heater further comprises a fixing block situated outside the cooling block and clamping the cooling block, for fixing the vacuum suction heater on a machine.

In some embodiments, the vacuum suction heater further comprises a sealing ring situated between the heating rod and the quartz blocks and/or the polyether ether ketone blocks.

In some embodiments, the vacuum suction heater further comprises a sealing ring situated on the quartz blocks and/or the polyether ether ketone blocks and around the through hole.

Brief Description of the Drawings

In order to provide a clearer explanation of the detailed description and the technical effects generated by present application, the following is a description of the detailed description of embodiments of present application in conjunction with drawings. In order to express clearly and facilitate the layout of the drawings, these figures are not entirely drawn to scale. For example, some figures are enlarged to show partial details, while others are shrunk to show the overall structure. For clarity, the drawings may not show all components of a given device or apparatus. Finally, throughout the entire description and drawings, the same reference signs are used to represent the same features. Wherein:

Fig. 1 is a three-dimensional schematic diagram of the overall structure of a vacuum suction heater according to some embodiments of the present application;

Fig. 2 is a top view of the heating plate of the vacuum suction heater shown in Fig. 1, which more clearly shows the first distribution pattern of grooves and protrusions in the upper surface of the main body of the heating plate (i.e. the surface used to support the wafer);

Fig. 2A is an enlarged view of A in Fig. 2, which particularly shows that the passing hole on the heating plate is located in the innermost ring groove, and the diameter is greater than the width of the ring groove;

Fig. 3 is similar to Fig. 2, which is also a top view of the heating plate, showing the second distribution of grooves and protrusions on the upper surface of the heating plate;

Fig. 4 is also similar to Fig. 2, which is a top view of the heating plate, showing the third distribution pattern of grooves and protrusions on the upper surface of the heating plate;

Fig. 5 is also similar to Fig. 2, which is a top view of the heating plate, showing the fourth distribution pattern of grooves and protrusions on the upper surface of the

heating plate;

Fig. 6 is also similar to Fig. 2, which is a top view of the heating plate, showing the fifth distribution pattern of grooves and protrusions on the upper surface of the heating plate;

Fig. 7 is also similar to Fig. 2, which is a top view of the heating plate, showing the sixth distribution pattern of grooves and protrusions on the upper surface of the heating plate;

Fig. 8 is also similar to Fig. 2, which is a top view of the heating plate, showing the seventh distribution pattern of grooves and protrusions on the upper surface of the heating plate;

Fig. 9 is the main view of the vacuum suction heater shown in Fig. 1, which shows the front structure of the vacuum suction heater;

Fig. 10 is a B-B sectional view of Fig. 9, which shows the internal structure of the vacuum suction heater at the sectional position;

Fig. 11 is a left view of the vacuum suction heater shown in Fig. 1, showing the side structure of the heater;

Fig. 12 is the C-C sectional view of Fig. 11, which shows the internal structure of the vacuum suction heater at the sectional position;

Fig. 12A is an enlarged view at point D of Fig. 12, which roughly shows the vertical structure of protrusions, grooves, and passing holes; and

Fig. 13 is a schematic diagram of the structure of a vacuum suction system according to some embodiments of the present application.

Detailed Description of Embodiments

A specific embodiment of the present application will be described in conjunction with the drawings below. It is easier to understand various aspects of the present application by reading the description of the specific embodiments referring to the drawings below. It should be noted that these embodiments are only illustrative and are intended to explain and illustrate the technical proposals of the present application, rather than limiting the present application. Based on these embodiments, those skilled in the art in this field can make various modifications and

transformations (such as changing the size and/or layout of grooves and protrusions on the upper surface of the main body of the heating plate). All technical proposals obtained through equivalent transformation are within the scope of protection of present application.

The names of various components used in this description are for illustrative purposes only and do not have a limiting effect. Different manufacturers may use different names to refer to components with the same function.

Vacuum suction heater

Fig. 1 is a three-dimensional schematic diagram of the overall structure of a vacuum suction heater according to some embodiments of the present application. As shown in Fig. 1, the vacuum suction heater mainly comprises a heating plate 10. The heating plate 10 comprises a generally disc-shaped main body 1 and a supporting shaft 2 situated below the main body 1.

As shown in Fig. 1, the main body 1 has an upper surface 11 for bearing the wafer. During the processing, the main body 1 of the heating plate 10 is situated in a reaction chamber. The wafer (not shown in the figures) can be placed on the upper surface 11 of the main body 1 through a mechanical arm or other conveying devices, and then fixed by vacuum suction. It can be subjected to deposition treatment and other operations after fixing the wafer.

Referring to Fig. 1 in conjunction with Figs. 9-12, in some embodiments of the present application, the main body 1 of the heating plate 10 and the supporting shaft 2 situated below the main body (1) are integrated. For example, both can be made of ceramics and then formed into one by adhesion or welding. Compared with the heating plate that adopts a split structure (i.e. the body and supporting shaft are assembled together in a detachable way), this integrated structure in the application not only eliminates the steps of installing, fixing, and sealing these two, but also eliminates the sealing elements between them. Moreover, the sealing performance is greatly improved, there by effectively enhancing the vacuum suction effect.

Continuing with Fig.1 and Figs. 9-12, in terms of external structure, the vacuum suction heater further comprises a cooling block 50 situated outside the supporting shaft 2 and at least partially surrounding the supporting shaft 2, as well as a fixing

block 60 situated outside the cooling block 50 and clamping the cooling block 50. The fixing block 60 is used to fix the vacuum suction heater on a machine. The specific structures of the cooling block 50 and the fixing block 60 can both adopt designs known in this field, and will not be described here.

In terms of internal structure, the vacuum suction heater further comprises a heating element (not shown in the figures) situated inside the main body 1 and a heating rod 40 electrically connected to the heating element. The heating element may comprise but is not limited to a resistance wire. The heating rod 40 may comprise materials with good conductivity, such as copper, nickel, etc. The heating element, heating rod 40 and their electrical connections can all adopt designs known in this field, and will not be described here.

As shown in Figs.10 and 12, the supporting shaft 2 is a hollow structure that can accommodate a plurality of sequentially stacked quartz blocks 20 and/or polyether ether ketone (PEEK) blocks 30 inside. The heating rod 40 is situated inside the supporting shaft 2, goes through the quartz blocks 20 and/or the PEEK block 30, and can be electrically connected to an external power source. When the power is turned on, the heating element will generate heat and transfer the heat to the wafer on the main body 1 of the heating plate 10. Heating rod 40 also generates heat. The quartz blocks 20 and PEEK blocks 30 surrounding the heating rod 40 conducive to maintain little or no heat loss inside the supporting shaft 2, thereby facilitating transferring heat to the wafer for heating. Quartz block 20 and PEEK block 30 are also used to achieve electrical insulation between the internal components of supporting shaft 2.

In present application, a special design has been made for the structure of the main body 1 of the heating plate 10 (especially the upper surface 11 bearing the wafer). The details are as follows.

Referring to Fig. 1, Fig. 2 and Fig. 2A, Fig. 2 is a top view of the heating plate 10 shown in Fig. 1, and Fig. 2A is an enlarged view at point A in Fig. 2. In the present application, the main body 1 of the heating plate 10 further has the following structure:

♦ a plurality of grooves 12 extending downwards from the upper surface 11, wherein at least a portion of the plurality of grooves 12 are fluid connected to each other;

♦ one or more passing holes 13, which are fluid connected to at least one of the plurality of grooves 12; and

♦a plurality of protrusions 14 situated on the upper surface 11, which are used to support the wafer.

In some embodiments provided in present application, a plurality of grooves 12 and a plurality of protrusions 14 are generally uniformly distributed on the upper surface 11. Those skilled in the art in this field can understand that the plurality of grooves 12 and the plurality of protrusions 14 may not be uniformly distributed, or one of them may be uniformly distributed. For example, in some embodiments, the plurality of grooves 12 are generally uniformly distributed, while the plurality of protrusions 14 are unevenly distributed (for example, the protrusions in the middle are denser while the surrounding protrusions are sparser); in some embodiments, the plurality of protrusions 14 are generally uniformly distributed, while the plurality of grooves 12 are unevenly distributed (for example, the closer to the middle part, the denser the grooves, while the more outward, the sparser the grooves).

Unlike existing technology, in the present application, due to the protrusion 14 on the upper surface 11, a uniform point contact can be formed between the wafer and the upper surface 11 of the main body of the heating plate, and there can be a uniform gap between these two. That is, these protrusions 14 make the contact between the wafer and its bearing surface (i.e. the upper surface 11 of the main body 1) more uniform, which helps to make all parts of the wafer receive uniform suction force and uniform heating, thereby facilitating the fabricating of the wafer, ensuring the film quality of the wafer surface, and improving its qualification rate.

In some embodiments of the present application, as shown in Fig.1 and Fig.2, the plurality of grooves 12 comprise a plurality of annular grooves 121 arranged in concentric circumferences and radial grooves 122 that fluid connect the annular grooves 121. In one embodiment, all radial grooves 122 are fluid connected to their adjacent annular grooves 121, so that all annular grooves 121 and radial grooves 122 are fluid connected. Therefore, all grooves 12 are completely fluid connected. Therefore, by vacuuming one groove 12, all grooves 12 can be vacuumed, therefore providing suction force on the wafer.

In some embodiments of the present application, the widths of the annular groove 121 and the radial groove 122 are both 0.5-1.5mm, the depths are less than or equal to 1.0mm; the distance between two adjacent annular grooves 121 is 10-50mm. More preferably, the widths of the annular groove 121 and the radial groove 122 are both 0.5-1.0mm, the depths are less than or equal to 0.5mm; the distance between two adjacent circular grooves 121 is 15-50mm. The grooves with the above size range are not only convenient for processing, but also help to effectively achieve suction on the wafer. For illustrative purposes only, the drawings of present application show a specific number of annular grooves 121 and radial grooves 122. It should be understood that the heating plate 10 can contain any suitable number of annular grooves 121 and radial grooves 122.

Furthermore, as shown in Fig. 2 and Fig.2A, in some embodiments of the present application, the main body 1 may only comprise one passing hole 13, which is situated at one groove 12, such as on the innermost annular groove 121, thereby being fluid connected to the annular groove 121, as shown in Fig. 2A. In other embodiments, the passing hole 13 may also be situated at other grooves 12. In addition, as shown in Fig. 2A, the diameter of the passing hole 13 is greater than the width of the groove 12, for example, which can be 0.8-1.8mm. Due to the large depth of the passing hole, passing hole 13 with a diameter within this size range is easy to process and can achieve good suction effects. Setting only one passing hole 13 also simplifies the processing technology and saves processing costs. In other embodiments, a plurality of passing holes 13 may also be provided on the main body 1.

In some embodiments of the present application, as shown in the figures, each of the protrusions 14 may be roughly circular, but the present application is not limited to this. When making the main body 1 of the heating plate 10, protrusions 14 can be directly sintered onto the upper surface 11. In some embodiments, the diameter of each protrusion 14 is 1.0-3.0mm, and the height is less than or equal to 0.2mm; the distance between two adjacent protrusions 14 is 3-20mm. The protrusions with this size range are not only convenient for processing and forming (such as the design of the mold for the main body 1 of the heating plate 10), but also can effectively achieve uniform contact with the wafer. Preferably, the diameter of each protrusion 14 is 1.5-

2.5mm, and the height is less than or equal to 0.1mm; the distance between two adjacent protrusions 14 is 5-15mm. A protrusion with this size range is more conducive to its production and processing, as well as providing uniform contact with the wafer.

In order to achieve better technical results, when designing the structure of the upper surface 11 of the main body 1 of the heating plate 10, it needs to consider the combination of the distribution of grooves 12 and the distribution of protrusions 14. Several exemplary proposals will be described in conjunction with the attached drawings below. It should be understood that the distributions of the grooves 12 and the protrusions 14 are not limited to these proposals.

In the first type of proposal, as shown in Figs.2-4, the upper surface 11 of the main body 1 comprises a total of 7 annular grooves 121. The widths of the annular groove 121 and the radial groove 122 are both 1.0mm, the depths are 0.5mm; and the distance between two adjacent annular grooves 121 is 21.5mm. In this type of proposal, the annular grooves 121 are relatively dense, which make the suction force more uniform during the processing and have a good suction effect on the wafer.

In the first embodiment of this type of proposal, as shown in Fig. 2, the diameter of each protrusion 14 is 2.0mm and the height is 0.1mm; and the plurality of protrusions 14 are distributed along a circumference, thereby forming a plurality of concentric circumferences. The distances between two adjacent protrusions 14 situated on the same circumference and between two adjacent circumferences are 7mm. This structure is conducive to achieve uniform support for the wafer from the circumferential direction.

In the second embodiment of this type of proposal, as shown in Fig. 3, the diameter of each protrusion 14 is 2.0mm and the height is 0.1mm; and the plurality of protrusions 14 are distributed in a triangular shape (for example, the closest three protrusions 14 can form an equilateral triangle), and the distance between two adjacent protrusions 14 is 10mm.

In the third embodiment of this type of proposal, as shown in Fig. 4, the diameter of each protrusion 14 is 2.0mm and the height is 0.1mm; and the plurality of protrusions 14 are distributed in a triangular shape (for example, the closest three

protrusions 14 can form an equilateral triangle), and the distance between two adjacent protrusions 14 is 5mm.

In the second type of proposal, as shown in Figs.5-8, the upper surface 11 of the main body 1 comprises a total of four annular grooves 121. The widths of the annular groove 121 and the radial groove 122 are both 1.0mm, the depths are 0.5mm; and the distance between two adjacent circular grooves 121 is 43mm. In this type of proposal, the annular grooves 121 are relatively sparse, and the heating plate 10 with such a structure is more convenient for production and processing, and mold design and manufacturing are more convenient, thus reducing production costs.

In the first embodiment of this type of proposal, as shown in Fig. 5, the diameter of each protrusion 14 is 2.0mm and the height is 0.1mm; and the plurality of protrusions 14 are distributed along a circumference, thereby forming a plurality of concentric circumferences, and the distances between two adjacent protrusions 14 situated on the same circumference and between two adjacent circles are 7mm. This structure is conductive to achieve uniform support for the wafer from the circumferential direction.

In the second embodiment of this type of proposal, as shown in Fig. 6, the diameter of each protrusion 14 is 2.0mm and the height is 0.1mm; and the plurality of protrusions 14 are distributed along a circumference, thereby forming a plurality of concentric circumferences, and the distanced between two adjacent protrusions 14 situated on the same circumference and between two adjacent circumferences are 15mm. In this structure, the protrusions 14 are sparser, making it easier to process.

In the third embodiment of this proposal, as shown in Fig. 7, the diameter of each protrusion 14 is 2.0mm and the height is 0.1mm; and the plurality of protrusions 14 are distributed in a triangular shape (for example, the closest three protrusions 14 can form an equilateral triangle), and the distance between two adjacent protrusions 14 is 10mm.

In the fourth embodiment of this proposal, as shown in Fig. 8, the diameter of each protrusion 14 is 2.0mm and the height is 0.1mm; and the plurality of protrusions 14 are distributed in a triangular shape (for example, the closest three protrusions 14 can form an equilateral triangle), and the distance between two adjacent protrusions

14 is 5mm.

Those skilled in the art can understand that the distance between adjacent annular grooves 121 is the distance between the corresponding points of two annular grooves, that is, the distance between the corresponding point on the outermost edge (or center line or innermost edge) of one annular groove 121 and the corresponding point on the outermost edge (or center line or innermost edge) of another annular groove 121. The width of the groove refers to the distance between the corresponding points on the two edges of the groove, and the depth refers to the distance from the bottom surface of the groove to the top edge of the groove. Similarly, the distance between adjacent protrusions 14 also refers to the distance between the corresponding points on two protrusions 14 (such as the center of the protrusion).

Further referring to Fig. 12 and Fig. 12A, Fig. 12 is a sectional view showing a portion of the internal structure of the vacuum suction heater. Fig. 12A is an enlarged view at point D of Fig. 12, particularly showing the vertical structure of the protrusions 14, grooves 12 and passing hole 13 on the main body 1 of the heating plate 10. As shown in Fig. 12A, the diameter of passing hole 13 is greater than the width of groove 12. In some embodiments, the diameter of passing hole 13 can be between 0.8-1.8mm. This size design not only facilitates the processing of the passing hole 13, but also helps to achieve good suction effects.

As shown in Fig. 12, the vacuum suction heater further comprises a through hole 131 that goes through the quartz blocks 20 and/or PEEK blocks 30. The upper end of the through hole 131 is fluid connected to the passing hole 13, and the lower end can be fluid coupled to the vacuum pump during operation. Therefore, a vacuum pump can suck gas from the grooves 12 through the pipeline and through the through hole 131 and passing hole 13, causing a pressure difference between the back side and front side of the wafer, thereby sucking the wafer. In some embodiments, the diameter of the through hole 131 is 2-3mm; the depth of through hole 131 in each of the quartz blocks 20 or the PEEK blocks 30 is 20-25mm. Through holes with this depth and diameter are convenient for processing and production.

In order to improve the suction effect, as shown in Fig. 12, the vacuum suction heater further comprises a sealing ring 16 situated on the quartz block 20 and/or

PEEK block, and around the through hole 131, thereby improving the sealing effect and preventing or reducing gas leakage.

In addition, as shown in Fig. 12, the vacuum suction heater also comprises a sealing ring 15 situated between the heating rod 40 and the quartz blocks 20 and/or the PEEK blocks 30. The sealing ring 15 is installed on the heating rod 40 and clamped between two adjacent quartz blocks 20 and/or PEEK blocks 30, so it can be firmly fixed.

Vacuum suction system and methods for sucking a wafer

The following introduces the vacuum suction system provided in present application and the method of using the vacuum suction system to suck a wafer. This vacuum suction system can be used in conjunction with the vacuum suction heater described in this description, as well as with vacuum suction heaters with other structures, so as to suck wafers.

Refer to Fig. 13, which schematically illustrates a vacuum suction system according to an embodiment of the present application. This system is used for sucking and releasing the wafer (not shown in the figures) on the bearing surface (such as the upper surface 11 of the main body 1 of the heating plate 10 shown in Fig. 1) of the vacuum suction heater 200 situated inside the reaction chamber 100. The reaction chamber 100 has an extraction port 101; the vacuum suction heater 200 has a ventilation port 201 (for example, the ventilation port 201 can be fluid connected to the through hole 131 shown in Fig. 12). Although the entire vacuum suction heater 200 is shown in the figure to be situated inside the reaction chamber 100, but in actual product, maybe only a part of the vacuum suction heater 200 present, such as a part of the main body 1 and supporting shaft 2 of the heating plate 10 shown in Fig. 1 (such as the portion above the cooling block 50 (including the cooling block 50), is situated inside the reaction chamber 100.

As shown in Fig. 13, the vacuum suction system comprises:

♦ a first pipeline A, for fluid coupling the extraction port 101 of the reaction chamber 100 with a vacuum pump 300;

♦ a second pipeline B, for fluid coupling the ventilation port 201 of the vacuum suction heater 200 with the vacuum pump 300; and

♦ a third pipeline C, connected to the second pipeline B and used for supplying gas from a gas source 400 to the vacuum suction system. In some embodiments, the gas inside the gas source 400 can be nitrogen, which is relatively cheaper and less prone to chemical reactions. In other embodiments, other gases such as helium can also be used.

According to the embodiments of the present application, the gas in the gas source 400 can be supplied to the vacuum suction system as needed during the operation process, by the third pipeline C coupled with the gas source 400 fluid. Therefore, when using the vacuum suction system to suck the wafer, the pressure in the suction pipeline (such as the passing hole 13 and the through hole 131 shown in Fig. 12) inside the heater can be conveniently adjusted, during the sucking and releasing processes, thereby adjusting the pressure difference between the back side and front side of the wafer and achieving the purpose of adjusting the magnitude of the suction force. It goes without saying that this will help meet the various suction needs of the wafer. For example, when the processing technology of the wafer requires a large suction force, a small amount of gas can be introduced from the gas source 400 or not, to ensure that the vacuum suction system generates suction force on the wafer; while in processes that require lower suction force, a large amount of gas can be introduced from the gas source 400 into the vacuum suction system to offset some of the suction force generated by the vacuum pump 300.

Another technical effect of setting the third pipeline C is that gas can be introduced into the vacuum suction system from the gas source 400, thereby supplying the gas to the suction pipeline inside the heater during the process of releasing the wafer, and increasing the pressure on the back side of the wafer quickly to equal to or even greater than the pressure on the front side thereof, thus eliminating the suction force on the wafer in a short period of time and releasing the wafer. Compared with the existing technology that only relies on turning off the vacuum suction system and allowing the gas in the reaction chamber to flow automatically to the back side of the wafer, this proposal of the present application greatly improves the work efficiency.

The structure of a vacuum suction system according to some embodiments of

the present application is further described as following.

Referring to Fig. 13, in the vacuum suction system, a throttle valve TV is set on the first pipeline A to control the suction of gas from the reaction chamber 100 by the vacuum pump 300. In some embodiments, the pressure Pc inside the reaction chamber 100 can be measured by a pressure measuring device 102 (such as a pressure gauge or a vacuum gauge). The throttle valve TV can be adjusted according to the pressure Pc inside the reaction chamber 100, to control the gas flow in the first pipeline A, thereby controlling the pressure Pc inside the reaction chamber 100 to reach the desired level.

As shown in Fig. 13, the first valve CHCV-1 is set near the ventilation port 201 on the second pipeline B. The third pipeline C is connected downstream (i.e. the side closer to the vacuum pump 300) of the first valve CHCV-1 on the second pipeline B. A second valve CHCV-2 is set on the third pipeline C. In an embodiment, a pressure controller 401 is set on the third pipeline C to adjust the gas flow rate supplied to the vacuum suction system. As shown in the figure, the pressure controller 401 may comprise a mass flow controller module (MFM), a flow adjustable valve 402, and an air pressure measuring device 403 (such as a barometer or a vacuum gauge). Those skilled in the art should understand that the pressure controller 401 is not limited to the structure shown in the figure, and existing pressure controllers or devices with similar functions can all be used as pressure controllers 401.

Further refer to Fig. 13, the second pipeline B bifurcates downstream of the first valve CHCV-1 into the first manifold B1 and the second manifold B2; the other end of the first manifold B1 is connected to the first pipeline A between the extraction port 101 and the throttle valve TV of the reaction chamber 100, and a third valve CHCV-3 is set on the first manifold B1; the other end of the second manifold B2 is connected to the vacuum pump 300. In an embodiment, the other end of the second manifold B2 can be connected to the first manifold A between the vacuum pump 300 and the throttle valve TV. The fourth valve CHCV-4 is set on the second manifold B2. In an embodiment, a pressure measuring device 500 (such as a pressure gauge or a vacuum gauge) can also be set on the second manifold B2 to measure the pressure Pb in the second manifold B2, which can reflect the pressure in the suction pipeline

inside the heater.

In some embodiments, the first valve CHCV-1, the second valve CHCV-2, the third valve CHCV-3, and the fourth valve CHCV-4 are all electromagnetic pneumatic valves that can be fully open or closed as needed, thereby achieving control over the opening and closing of the corresponding pipelines. The use of electromagnetic pneumatic valves can achieve more precise control. In other embodiments, other types of valves may also be used.

Present application also provides a method for sucking a wafer by the above vacuum suction system. In short, in this method, a second pipeline B and a third pipeline C can be used to supply gas from a gas source 400 to a suction pipeline inside a vacuum suction heater during a process of sucking and/or releasing wafer, so as to adjust a pressure difference between back side and front side of the wafer.

According to some embodiments of the present application, the second pipeline B and the third pipeline C can be used to supply gas from the gas source 400 to the suction pipeline during the process of sucking wafer, maintaining a pressure difference between the back side of the wafer and the front side thereof, for example, maintaining pressure on the back side of the wafer 30-150 Torr lower than that on the front side thereof. During the process of releasing wafer, the second pipeline B and the third pipeline C can be used to supply gas from the gas source 400 to the suction pipeline, increasing the pressure on the back side of the wafer to greater than or equal to the pressure on the front side thereof, for example, increasing the pressure on the back side of the wafer to 5-10 Torr greater than the pressure on the front side thereof. At this point, the suction force is completely eliminated and there is a certain thrust on the back side of the wafer, making it easy to move the wafer to next workstation.

Overall, according to some embodiments of the present application, a method for sucking a wafer by the vacuum suction system mainly comprises the following steps:

(a) placing the wafer: placing the wafer on a bearing surface of a vacuum suction heater 200 in a reaction chamber 100 when the vacuum suction system is in an OFF state (i.e. both the second pipeline B and the third pipeline C are in an OFF state);

(b) sucking the wafer: turning on the vacuum suction system, and continuously

sucking gas from a suction pipeline inside the vacuum suction heater 200 through a second pipeline B, for maintaining pressure on the back side of the wafer lower than that on the front side thereof, thereby sucking the wafer onto the bearing surface of the vacuum suction heater 200; and

(c) releasing the wafer: stop sucking gas from the suction pipeline inside the vacuum suction heater 200 after processing the wafer, and supplying gas from a gas source 400 to the suction pipeline inside the vacuum suction heater 200 through the second pipeline B and a third pipeline C, for increasing the pressure on the back side of the wafer to greater than or equals to the pressure on the front side thereof, therefore releasing the wafer.

In some embodiments, the above method may also comprise at least one of the following steps:

(a1) heating the bearing surface of the vacuum suction heater 200 (e.g. heating to 450-500℃) and sucking the reaction chamber 100 to vacuum state by a vacuum pump 300 before the step (a); and

(a2) injecting gas into the reaction chamber 100 (which can be through other pipelines, not shown in the figures), for increasing pressure Pc inside the reaction chamber 100 (as needed, Pc can be increased to 200-600 Torr, and the pressure above the throttle valve TV can all reach 200 Torr) after the step (a) and before the step (b).

In one embodiment of the present application, in the step (a2), the step (b) will start when the pressure Pc inside the reaction chamber 100 increased above a threshold (e.g. 100Torr). In the step (b), at the same time of continuously sucking gas from the suction pipeline inside the vacuum suction heater (200) by the vacuum pump (300), gas from the gas source (400) is supplied to the suction pipeline inside the vacuum suction heater 200 through the second pipeline (B) and third pipeline (C), thereby maintaining the pressure on the back side of the wafer 30-150 Torr lower than the pressure on the front side thereof. The specific pressure difference can be adjusted according to the needs of wafer suction force.

As mentioned above, a throttle valve TV is set on the first pipeline A; a first valve CHCV-1 is set near the ventilation port 201 on the second pipeline B; the third

pipeline C is connected downstream of the first valve CHCV-1 on the second pipeline B, and a second valve CHCV-2 is set on the third pipeline C; the second pipeline B bifurcates downstream of the first valve CHCV-1 into a first manifold B1 and a second manifold B2; the other end of the first manifold B1 is connected to the first pipeline A between an extraction port 101 and the throttle valve TV of the reaction chamber 100, and a third valve CHCV-3 is set on the first manifold B1; the other end of the second manifold B2 is connected to a vacuum pump 300 (for example, to the first manifold A between the vacuum pump 300 and the throttle valve TV, as shown in Fig. 13), and a fourth valve CHCV-4 is set on the second manifold B2. The specific working process of these valves and their corresponding pipelines is as follows:

In the step (a1), the first valve CHCV-1, the second valve CHCV-2, the third valve CHCV-3 and the fourth valve CHCV-4 are all closed, and the throttle valve TV is open, so that only the first pipeline A is in a path state. Through this, the vacuum pump 300 draws the reaction chamber 100 to a vacuum state. These valves remain in this state during the step (a) (i.e. placing the wafer) and step (a2).

In the step (b) (i.e. sucking the wafer), the first valve CHCV-1, the second valve CHCV-2 and the fourth valve CHCV-4 are all open, and the third valve CHCV-3 is closed. The vacuum pump 300 continues to extract gas from the reaction chamber 100 through the first pipeline A, maintaining the required level of pressure Pc in the reaction chamber 100 (e.g. 200 Torr). At this time, the second pipeline B, the second manifold pipeline B2 and the third pipeline C are in a path state, the vacuum pump 300 thereby extracting the gas in the suction pipeline inside the vacuum suction heater 200 (i.e. gas on the back side of the wafer). At the same time, gas source 400 can introduce gas into the vacuum suction system, and the amount of gas introduced (i.e. gas flow rate in the third pipeline C) can be controlled by adjusting the pressure controller 401. Under the combined action of the gas extracted from the suction pipeline of the vacuum suction heater 200 by vacuum pump 300 through the second pipeline B and the second pipeline B2, as well as the gas source 400 introducing gas into the suction pipeline through the third pipeline C, the pressure on the back side of the wafer 30-150 Torr is maintained lower than the pressure on the front side thereof. The specific pressure difference can be set as needed.

In the step (c) (i.e. releasing the wafer), the first valve CHCV-1, the second valve CHCV-2 and the third valve CHCV-3 are all open, and the fourth valve CHCV-4 is closed. The vacuum pump 300 continues to extract gas from the reaction chamber 100 through the first pipeline A, to maintain the required level of pressure Pc in the reaction chamber 100 (e.g. 200 Torr). At this time, on one hand, the gas inside the reaction chamber 100 can enter the suction pipeline inside the vacuum suction heater through the first pipeline A, the first manifold pipeline B1 and the second pipeline B, thereby reaching the back side of the wafer. On the other hand, external gas (such as nitrogen) from the gas source 400 enters the suction pipeline inside the vacuum suction heater through the third pipeline C and the second pipeline B, thereby reaching the back side of the wafer. Due to the effects of these two gases, the pressure on the back side of the wafer increases rapidly, and the pressure difference with the front side decreases rapidly. Even gas flow rate in the third pipeline (C) is adjusted by the pressure controller 401, increasing the pressure on the back side of the wafer to equals to or greater than the pressure on the front side thereof, for example, increasing the pressure on the back side of the wafer to 5-10 Torr greater than the pressure on the front side thereof, so that the suction force can be quickly eliminated, and the wafer can be quickly released. Obviously, this operating method greatly improves work efficiency.

The technical content and features of present application have been described by the relevant embodiments above, however, the above embodiments are only examples of implementing present application. The skilled in the art may still make various substitutions and modifications based on the instructions and disclosures of present application that do not deviate from the spirit of present application. Therefore, the disclosed embodiments of present application do not limit the scope of present application. On the contrary, modifications and equal proposals that do not deviate from the spirit and scope of present application are included within the scope of present application.

Claims

1. A vacuum suction heater, comprising:

a heating plate (10), wherein the heating plate (10) comprises a generally disc-shaped main body (1), and a supporting shaft (2) situated below the main body (1), wherein the supporting shaft (2) is a hollow structure and integrated with the main body (1);

a plurality of sequentially stacked quartz blocks (20) and/or polyether ether ketone blocks (30) situated inside the supporting shaft (2); and

a heating element situated inside the main body (1) and a heating rod (40) electrically connected to the heating element, wherein the heating rod (40) is situated inside the supporting shaft (2), goes through the quartz blocks (20) and/or the polyether ether ketone blocks (30), and can be electrically connected to an external power source.

2. The vacuum suction heater according to claim 1, wherein: the main body (1) has an upper surface (11) for bearing a wafer, and further comprises:

a plurality of grooves (12) extending downwards from the upper surface (11), wherein at least a portion of the plurality of grooves (12) are fluid connected to each other;

one or more passing holes (13), which are fluid connected to at least one of the plurality of grooves (12); and

a plurality of protrusions (14) situated on the upper surface (11), which are used to support the wafer.

3. The vacuum suction heater according to claim 2, further comprising a through hole (131), which goes through the quartz blocks (20) and/or the polyether ether ketone blocks (30), fluid connects the passing hole (13), and can be fluid coupled to a vacuum pump during operation.

4. The vacuum suction heater according to claim 3, wherein a diameter of the through hole (131) is 2-3mm; a depth of the through hole (131) in each of the quartz blocks (20) or the polyether ether ketone blocks (30) is 20-25mm.

5. The vacuum suction heater according to claim 2, wherein each of the protrusions (14) is generally circular, a diameter thereof is 1.0-3.0mm, and a height is less than or equal to 0.2mm; a distance between two adjacent protrusions (14) is 3-20mm.

6. The vacuum suction heater according to claim 5, wherein: the plurality of grooves (12) comprise a plurality of annular grooves (121) arranged in concentric circumferences and a radial groove (122) that fluid connect the annular grooves (121), widths of the annular groove (121) and the radial groove (122) are both 0.5-1.5mm and depths are less than or equal to 1.0mm; a distance between two adjacent annular grooves (121) is 10-50mm.

7. The vacuum suction heater according to claim 6, wherein:

the diameter of each of the protrusions (14) is 1.5-2.5mm, and the height is less than or equal to 0.1mm; the distance between two adjacent protrusions (14) is 5-15mm;

the widths of the annular groove (121) and the radial groove (122) are both 0.5-1.0mm, and the depths are less than or equal to 0.5mm; the distance between two adjacent annular grooves (121) is 15-50mm.

8. The vacuum suction heater according to claim 7, wherein:

the widths of the annular groove (121) and the radial groove (122) are both 1.0mm, the depths are 0.5mm; and the distance between two adjacent annular grooves (121) is 21.5mm.

9. The vacuum suction heater according to claim 8, wherein:

the diameter of each of the protrusions (14) is 2.0mm and the height is 0.1mm;

and

the plurality of protrusions (14) are distributed along a circumference, thereby forming a plurality of concentric circumferences, and the distances between two adjacent protrusions (14) situated on the same circumference and between two adjacent circumferences are 7mm.

10. The vacuum suction heater according to claim 8, wherein:

the diameter of each of the protrusions (14) is 2.0mm and the height is 0.1mm; and

the plurality of protrusions (14) are distributed in a triangular shape, and the distance between two adjacent protrusions (14) is 10mm or 5mm.

11. The vacuum suction heater according to claim 7, wherein:

the widths of the annular groove (121) and the radial groove (122) are both 1.0mm, the depths are 0.5mm; and the distance between two adjacent annular grooves (121) is 43mm.

12. The vacuum suction heater according to claim 11, wherein:

the diameter of each of the protrusions (14) is 2.0mm and the height is 0.1mm; and

the plurality of protrusions (14) are distributed along a circumference, thereby forming a plurality of concentric circumferences, and the distances between two adjacent protrusions (14) situated on the same circumference and between two adjacent circumferences are 7mm or 15mm.

13. The vacuum suction heater according to claim 11, wherein:

the diameter of each of the protrusion (14) is 2.0mm and the height is 0.1mm; and

the plurality of protrusions (14) are distributed in a triangular shape, and the distance between two adjacent protrusions (14) is 10mm or 5mm.

14. The vacuum suction heater according to claim 2, wherein: the plurality of grooves (12) and/or the plurality of protrusions (14) are generally uniformly distributed on the upper surface (11).

15. The vacuum suction heater according to claim 2, wherein the main body (1) comprises only one passing hole (13), the passing hole (13) is situated in one of the grooves (12), and a diameter thereof is greater than the width of the groove (12).

16. The vacuum suction heater according to claim 15, wherein the diameter of the passing hole (13) is 0.8-1.8mm.

17. The vacuum suction heater according to claim 1, wherein a diameter of the through hole (131) is 2-3mm; a depth of the through hole (131) in each of the quartz blocks (20) or the polyether ether ketone blocks (30) is 20-25mm.

18. The vacuum suction heater according to claim 17, further comprising a fixing block (60) situated outside the cooling block (50) and clamping the cooling block (50), for fixing the vacuum suction heater on a machine.

19. The vacuum suction heater according to claim 1, further comprising a sealing ring (15) situated between the heating rod (40) and the quartz blocks (20) and/or the polyether ether ketone blocks (30).

20. The vacuum suction heater according to claim 3, further comprising a sealing ring (16) situated on the quartz blocks (20) and/or the polyether ether ketone blocks and around the through hole (131).