SHOWERHEAD

FIELD OF THE INVENTION

The present invention belongs to the technical field of semiconductors, and relates to a showerhead used in a substrate processing apparatus.

BACKGROUND

In the process of Plasma Enhanced Chemical Vapor Deposition (PECVD) equipment processing a substrate, various dielectric thin films are deposited on the substrate surface. The thickness uniformity of the thin films directly affects thin film characteristics and production yield.

Process gas enters the interior of the equipment through a showerhead of the PECVD equipment and deposits thin films on the substrate surface. The uniformity of gas flow exerts a great influence on the uniformity of thin films deposited on the substrate surface. Gas flow is difficult to control, so the showerhead with a reasonable structural design can make the gas flow meet process requirements. It is critical to design a showerhead capable of adjusting gas flow.

SUMMARY

The objective of the present invention is to provide a showerhead capable of adjusting output gas flow rate, which can improve the thickness uniformity of thin films deposited on the substrate surface during a PECVD process.

To achieve the above objective and other related objectives, the present invention proposes a showerhead, comprising: a faceplate, including a first surface, a second surface, and a plurality of through holes penetrating the first surface and the second surface; an inflation cavity, at least partially defined by the first surface of the faceplate; wherein the second surface is opposite to a substrate support member disposed below the showerhead, and the first surface protrudes in a direction away from the substrate support member, such that the length of the plurality of through holes reaches the maximum at the center of the faceplate and the minimum at the edge of the faceplate.

Optionally, the first surface is a smooth surface.

Optionally, the first surface is a stepped surface.

Optionally, the distance between the second surface and the substrate support member is consistent.

Optionally, the thickness of the faceplate gradually decreases from the center to the edge of the faceplate.

Optionally, the showerhead further comprises a gas inlet for introducing gas into the inflation cavity, wherein the vertical distance between the second surface and the gas inlet gradually increases from the center to the edge of the faceplate.

Optionally, a baffle plate is further arranged inside the inflation cavity, and the central axis of the baffle plate is collinear with the central axis of the gas inlet.

Optionally, the baffle plate includes a circular baffle plate and annular baffle plates, the annular baffle plates are disposed between the circular baffle plate and the faceplate, such that gas flows to the annular baffle plates after passing through the circular baffle plate and diffuses to the first surface of the faceplate through the central hole and the edges of the annular baffle plates.

Optionally, the showerhead further comprises a backplate, wherein the inner surface of the backplate opposite to the first surface at least partially defines a flow guiding portion.

As described above, in the showerhead of the present invention, the gas flow rate gradually decreases from the center to the edge of the faceplate on the first surface, while the length of the through holes gradually decreases from the center to the edge of the faceplate. Accordingly, the resistance applied to the gas by the through holes gradually decreases from the center to the edge of the faceplate, which improves the uniformity of gas flow rate discharged from the second surface of the faceplate and regulates the uniformity of film thickness deposited on the substrate surface.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a schematic structural diagram of a showerhead according to one embodiment of the present invention.

FIG. 2 is a schematic structural diagram of a showerhead according to another embodiment of the present invention.

FIG. 3 is a schematic structural diagram of a showerhead according to yet another embodiment of the present invention.

PREFERRED EMBODIMENTS OF THE APPLICATION

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

When describing the embodiments of the present invention in detail, cross-sectional diagrams showing device structures may be partially enlarged out of general scales for the convenience of illustration, and the schematic diagrams are merely examples, which shall not limit the protection scope of the present invention here. Besides, in actual manufacturing, three-dimensional spatial dimensions including length, width, and depth should be included.

For convenience of description, spatial relational terms such as "below," "beneath," "lower than," "underneath," "above," and "on" may be used herein to describe the relationship between one element or feature and other elements or features shown in the accompanying drawings. It will be understood that these spatial relational terms intend to include other orientations of the device during use or operation in addition to the orientation depicted in the accompanying drawings. In addition, 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 exist. The term "between... and..." as used herein includes both endpoint values.

In the context of the present application, a structure where a first feature is disposed "on" a second feature may include embodiments where the first and second features are in direct contact, and may also include embodiments where additional features are formed between the first and second features, such that the first and second features may not be in direct contact.

It should be noted that the drawings provided in the present embodiments merely illustrate the basic concept of the present invention in a schematic manner, so the drawings only show components related to the present invention and are not drawn according to the number, shape, and size of components in actual implementation. In actual implementation, the shape, quantity, and proportion of each component may be arbitrarily changed, and the component layout may also be more complex.

For the purpose of the present disclosure, the term "fluidly connected" is used for volumes, gas chambers, holes, and the like that may be connected to each other to form a fluid communication.

As shown in FIG. 1, the present embodiment provides a showerhead 100 comprising a gas inlet 210 fluidly connected to other fluid pipeline hardware, such as pipelines and valves. Exemplarily, in FIG. 1, the gas inlet 210 is fluidly connected to a pipeline 211, and the pipeline 211 may be a rod for suspending the showerhead 100. The showerhead 100 further comprises a backplate 230, a faceplate 220, and an inflation cavity 240. Wherein, the backplate 230 is in communication with the pipeline 211 and is disposed opposite to the faceplate 220, and the backplate 230 and the faceplate 220 at least partially define the inflation cavity 240. An external gas supply device supplies gas into the inflation cavity 240 through the gas inlet 210. Exemplarily, the gas inlet 210 is an opening formed on the backplate 230. Gas from the external gas supply device sequentially passes through the pipeline 211 and the gas inlet 210 and is then introduced into the inflation cavity 240.

As shown in FIG. 1, the faceplate 220 includes a first surface 221, a second surface 222, and a plurality of through holes 223 penetrating the first surface 221 and

the second surface 222, and the first surface 221 of the faceplate 220 at least partially defines the inflation cavity 240. The first surface 221 is a non-planar surface, and the second surface 222 is a planar surface. The second surface 222 is disposed opposite to a substrate support member (not shown), and the distance between the second surface 222 and the substrate support member is consistent. More specifically, the distance between the second surface 222 and the substrate support member remains consistent over the entire extending direction. The second surface 222 is closer to the substrate support member relative to the first surface 221, and the first surface 221 protrudes in a direction away from the substrate support member. After gas flows out from the through holes 223 of the faceplate 220, the gas is dissociated into plasma below the faceplate 220, and the dissociated plasma deposits thin films on the surface of a substrate placed on the substrate support member. Specifically, in one embodiment, radio frequency power is applied between the showerhead 100 serving as an upper electrode and the substrate support member serving as a lower electrode to excite gas flowing out from the faceplate 220 into plasma for substrate processing. The first surface 221 and the second surface 222 extend from the center of the faceplate 220 to an edge 229 of the faceplate 220, and the thickness of the faceplate 220 gradually decreases from the center of the faceplate 220 to the edge 229 of the faceplate 220. Exemplarily, in the embodiment shown in FIG. 1, the first surface 221 may be a slightly conical surface, and the first surface 221 inclines downward from the center to the edge 229 of the faceplate 220 to gradually reduce the thickness of the faceplate 220. In the cross-section of the first surface 221, the section from the center to the edge 229 of the faceplate 220 is an inclined straight line. In an unillustrated embodiment, the cross-section of the first surface from the center to the edge of the faceplate may be a curve, and the thickness of the faceplate is reduced from the center to the edge of the first surface in a curved manner. In the embodiment of FIG. 1, the first surface 221 is a smooth surface. In the embodiments shown in FIG. 2 and FIG. 3, the first surface 221 may be a stepped surface or a step-shaped surface, and the first surface 221 reduces the thickness of the faceplate 220 in a stepped manner from the center to the edge 229 of the faceplate 220. With reference to FIG. 1, the vertical distance between the second surface 222 and the gas inlet 210 gradually increases from the center of the faceplate 220 to the edge 229 of the faceplate 220. The length (vertical direction in the drawing) of the through holes 223 reaches the maximum at the center of the faceplate 220 and the minimum at the edge 229 of the faceplate 220. Exemplarily, as shown in the

embodiment of FIG. 1, the length of the through holes 223 penetrating the first surface 221 and the second surface 222 of the faceplate 220 gradually decreases from the center to the edge 229 of the faceplate 220. The gas inlet 210 is fluidly connected to the inflation cavity 240, and gas enters the inflation cavity 240 from the gas inlet 210 and flows along the first surface 221 from the center of the faceplate 220 to the edge 229. The gas flow rate gradually decreases from the center to the edge 229 of the faceplate 220 on the first surface 221, while the length of the through holes 223 gradually decreases from the center to the edge 229 of the faceplate 220. Accordingly, the resistance applied to the gas passing through the through holes 223 gradually decreases from the center to the edge 229 of the faceplate, which improves the uniformity of gas flow rate discharged from the second surface 222 of the faceplate 220.

In some embodiments, the inner surface of the backplate 230 opposite to the first surface 221 of the faceplate 220 at least partially defines a flow guiding portion. As shown in the embodiment of FIG. 2, the inner surface of the backplate 230 opposite to the first surface 221 of the faceplate 220 defines a flow guiding portion 231. Gas is introduced into the inflation cavity 240 from the gas inlet 210, and flows radially outward and toward the faceplate 220 from the gas inlet 210 under the flow guiding effect of the flow guiding portion 231. The inner surface of the backplate 230 in FIG. 2 is a downward inclined surface extending radially outward, and the inclined surface serves as the flow guiding portion 231. As shown in the embodiment of FIG. 3, the inner surface of the backplate 230 opposite to the first surface 221 of the faceplate 220 partially defines a flow guiding portion 232. Gas is introduced into the inflation cavity 240 from the gas inlet 210, and flows toward the edge 229 of the faceplate 220 under the flow guiding effect of the flow guiding portion 232. The partial inner surface of the backplate 230 in FIG. 3 includes a downward inclined surface extending radially outward, and the inclined surface serves as the flow guiding portion 232. Compared to the area of the downward inclined surface of the backplate 230 in FIG. 3, the area of the downward inclined surface of the backplate 230 in the embodiment in FIG. 2 is larger than the area of the downward inclined surface of the backplate 230 in FIG. 3, so the volume of the inflation cavity 240 defined by the backplate 230 and the faceplate 220 in FIG. 3 is smaller than the volume of the inflation cavity 240 in FIG. 2. Gas from the external gas supply device can fill the inflation cavity 240 in FIG. 3 more quickly, which can shorten the time for process gas to reach the substrate surface from the

inflation cavity 240, and also reduce the time for purging and removing process gas in the inflation cavity 240 by cleaning gas.

In some embodiments, a baffle plate may be arranged inside the showerhead 100 to improve the flow rate distribution of gas in the inflation cavity 240. Specifically, the baffle plate is centrally disposed below the gas inlet 210. Exemplarily, with reference to the embodiment shown in FIG. 2, a baffle plate 260 is centrally disposed below the gas inlet 210, and the baffle plate 260 includes a circular baffle plate 261. Gas enters the inflation cavity 240 from the gas inlet 210 and reaches the circular baffle plate 261, and diffuses radially outward under the action of the circular baffle plate 261. In another embodiment, with reference to the embodiment shown in FIG. 2, the baffle plate 260 includes the circular baffle plate 261 and annular baffle plates 262, and the annular baffle plates 262 are disposed between the circular baffle plate 261 and the faceplate 220. Gas enters the inflation cavity 240 from the gas inlet 210 and reaches the circular baffle plate 261, flows transversely under the action of the circular baffle plate 261, and flows toward the faceplate 220 through the edges of the annular baffle plates 262 and the central hole 263 between the annular baffle plates 262. Exemplarily, the diameter of the circular baffle plate 261 is larger than the diameter of the central hole 263, which can better guide gas to flow transversely. The central axis of the gas inlet 210 is collinear with the central axis of the faceplate 220, and the central axes of the circular baffle plate 261 and the annular baffle plates 262 are collinear with the central axis of the gas inlet 210; in other words, the central axes 228 of the gas inlet 210, the faceplate 220, the circular baffle plate 261, and the annular baffle plates 262 are collinear. With reference to the embodiment shown in FIG. 2, the circular baffle plate 261 and the annular baffle plates 262 are fixed to the backplate 230 through fixing columns 264.

In the present embodiment, gas enters the inflation cavity 240 from the gas inlet 210 and flows along the first surface 221 from the center to the edge 229 of the faceplate 220. The gas flow rate gradually decreases from the center to the edge 229 of the faceplate 220 on the first surface 221, while the length of the through holes 223 gradually decreases from the center to the edge 229 of the faceplate 220. Accordingly, the resistance applied to gas passing through the through holes 223 gradually decreases from the center to the edge 229 of the faceplate, which improves the uniformity of gas

flow rate discharged from the faceplate 220 and regulates the uniformity of film thickness deposited on the substrate surface.

The above embodiments merely illustratively explain the principles and effects of the present invention, and are not intended to limit the present invention. Any person skilled in the art may modify or change the above embodiments without departing from the spirit and scope of the present invention. Therefore, all equivalent modifications or changes completed by those of ordinary skill in the art without departing from the spirit and technical idea disclosed by the present invention shall still be covered by the claims of the present invention.

What is claimed is:

1. A showerhead, comprising:

a faceplate, including a first surface, a second surface, and a plurality of through holes penetrating the first surface and the second surface;

an inflation cavity, at least partially defined by the first surface of the faceplate;

wherein the second surface is opposite to a substrate support member disposed below the showerhead, and the first surface protrudes in a direction away from the substrate support member, such that the length of the plurality of through holes reaches the maximum at the center of the faceplate and the minimum at the edge of the faceplate.

2. The showerhead according to claim 1, wherein the first surface is a smooth surface.

3. The showerhead according to claim 1, wherein the first surface is a stepped surface.

4. The showerhead according to claim 1, wherein the distance between the second surface and the substrate support member is consistent.

5. The showerhead according to claim 1, wherein the thickness of the faceplate gradually decreases from the center to the edge of the faceplate.

6. The showerhead according to claim 1, wherein the showerhead further comprises a gas inlet for introducing gas into the inflation cavity, and the vertical distance between the second surface and the gas inlet gradually increases from the center to the edge of the faceplate.

7. The showerhead according to claim 1, wherein a baffle plate is further arranged inside the inflation cavity, and the central axis of the baffle plate is collinear with the central axis of a gas inlet.

8. The showerhead according to claim 7, wherein the baffle plate includes a

circular baffle plate and annular baffle plates, the annular baffle plates are disposed between the circular baffle plate and the faceplate, such that gas flows to the annular baffle plates after passing through the circular baffle plate and diffuses to the first surface of the faceplate through the central hole and the edges of the annular baffle plates.

9. The showerhead according to claim 1, wherein the showerhead further comprises a backplate, the inner surface of the backplate opposite to the first surface at least partially defines a flow guiding portion.