

FURNACE TUBE APPARATUS

TECHNICAL FIELD

The present invention relates to the technical field of semiconductor equipment, and specifically relates to a furnace tube apparatus.

BACKGROUND

As the size of semiconductor devices decreases, the requirements for thin-film deposition techniques over large substrate regions are increasing. Depositing semiconductor thin films with more uniform composition and thickness is critical for manufacturing high-quality semiconductor devices. Currently, furnace tube-based chemical vapor deposition (CVD) and furnace tube-based atomic layer deposition (ALD) hold a dominant market share in semiconductor thin-film preparation.

Existing furnace tube apparatuses all adopt a single evacuation port design. In a dual-tube furnace, the inner tube and outer tube of the furnace tube apparatus are connected, and the evacuation port is typically disposed on the outer tube, resulting in low evacuation efficiency during evacuation.

SUMMARY

The technical problem to be solved by the present invention is to overcome the defect of low evacuation efficiency of furnace tube apparatuses in the prior art.

The present invention solves the technical problem described above through the following technical solutions:

providing a furnace tube apparatus, comprising:

an inner tube, forming a process space inside the inner tube;

an outer tube, sleeved outside the inner tube, a gap region being present between the outer tube and the inner tube, and the inner tube being provided with an exhaust port to connect the process space and the gap region;

a first evacuation port, connected to the process space;

a second evacuation port, connected to the gap region.

The positive and progressive effects of the present invention are as follows: In the present invention, the first evacuation port is in direct communication with the process space, and the second evacuation port is in direct communication with the gap region. Compared with the single evacuation port design, this design exhibits higher evacuation efficiency. If an evacuation port is provided on the outer tube only, although an exhaust port is disposed on the inner tube during evacuation, the evacuation efficiency is still affected by the obstruction of the inner tube wall. The gas in the process space can be directly evacuated through the first evacuation port, and the gas in the gap region between the inner tube and the outer tube can be directly evacuated through the second evacuation port. During the process, gas can be discharged more quickly, thereby improving the production efficiency of the furnace tube apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a schematic structural diagram of the furnace tube apparatus according to embodiment 1 of the present invention;

FIG. 2 is a schematic structural diagram of the furnace tube apparatus according to embodiment 2 of the present invention;

FIG. 3 is a schematic structural diagram of the furnace tube apparatus according to embodiment 3 of the present invention.

PREFERRED EMBODIMENTS OF THE PRESENT INVENTION

The present invention is further described below by way of embodiments, but the present invention is not limited to the scope of the embodiments.

Embodiment 1

As shown in FIG. 1, this embodiment provides a furnace tube apparatus, comprising an inner tube 100, an outer tube 200, a first evacuation port 300, and a second evacuation port 400. A process space S1 is formed inside the inner tube 100. The outer tube 200 is sleeved outside the inner tube 100, a gap region S2 is present between the outer tube 200 and the inner tube 100, and the inner tube 100 is provided with an exhaust port 110 to connect the process space S1 and the gap region S2. The first evacuation port 300 passes through the outer tube 200 and the gap region S2 and is disposed on the inner tube 100, and the first evacuation port 300 is in communication with the process space S1. The second evacuation port 400 is disposed on the outer tube 200, and the second evacuation port 400 is in communication with the gap region S2.

In the present invention, the first evacuation port 300 is in direct communication with the process space S1, and the second evacuation port 400 is in direct communication with the gap region S2. Compared with the single evacuation port design, evacuation through the two evacuation ports together results in higher evacuation efficiency. If an evacuation port is provided on the outer tube 200 only, although an exhaust port 110 is disposed on the inner tube 100 during evacuation, the evacuation efficiency is still affected by the obstruction of the tube wall of the inner tube 100. The gas in the process space S1 can be directly evacuated through the first evacuation port 300, and the gas in the gap region S2 between the inner tube 100 and the outer tube 200 can be directly evacuated through the second evacuation port 400. During the process, gas can be discharged more quickly, thereby improving the production efficiency of the furnace tube apparatus.

The number and position of exhaust ports 110 are not limited to the solution shown in FIG. 1, and can be flexibly set as required.

In this embodiment, both the inner tube 100 and the outer tube 200 are made of quartz, but the present application is not limited thereto. In this embodiment, the material of the first evacuation port 300 is the same as the material of the inner tube 100, and the material of the second evacuation port 400 is the same as the material of the outer tube 200. In one aspect, processing materials of the same composition together is less difficult; in another aspect, during heating, the inner tube 100 and the first evacuation port 300 have the same thermal expansion coefficient, and the outer

tube 200 and the first evacuation port 300 have the same thermal expansion coefficient. The inner tube 100, the outer tube 200, the first evacuation port 300, and the second evacuation port 400 are less prone to breakage and more stable when heated.

In some embodiments, the outer tube 200 and the second evacuation port 400 may also be made of silicon carbide.

Regarding the processing method of the inner tube 100, the outer tube 200, the first evacuation port 300, and the second evacuation port 400, welding is adopted in this embodiment. The inner tube 100, the outer tube 200, the first evacuation port 300, and the second evacuation port 400 are processed separately and then welded together to form an integral unit.

The bottom end of the gap region S2 between the inner tube 100 and the outer tube 200 is closed, which is beneficial to maintaining the overall sealing performance of the furnace tube apparatus.

A substrate reacts in the process space S1, so it is necessary to ensure that the gas in the process space S1 is evacuated quickly first. Therefore, in this embodiment, the aperture of the first evacuation port 300 is larger than the aperture of the second evacuation port 400. In this way, the gas in the process space S1 can be preferentially discharged during evacuation, helping increase the gas discharge rate in the process space S1.

Taking the ALD process as an example, when a precursor gas or a reaction gas is supplied, evacuation can be performed only through the second evacuation port 400 to ensure the fluidity of the precursor gas or the reaction gas in the furnace tube apparatus and avoid excessive internal pressure. In the purging stage, evacuation can be performed simultaneously through the first evacuation port 300 and the second evacuation port 400, which can evacuate excess precursor gas, reaction gas, and by-products more quickly from the inner tube 100, thereby improving film quality.

In this embodiment, the furnace tube apparatus further comprises a heating assembly 700 disposed outside the outer tube 200, and the first evacuation port 300 and the second evacuation port 400 are located below the heating assembly 700. In this

embodiment, the first evacuation port 300 and the second evacuation port 400 are at the same height, so the layout of the first evacuation port 300 and the second evacuation port 400 is more compact, and the first evacuation port 300 and the second evacuation port 400 do not occupy additional space in the vertical direction, which can otherwise affect the installation of the heating assembly 700.

In this embodiment, the furnace tube apparatus further comprises at least two evacuation pumps (not shown), which are respectively connected to the first evacuation port 300 and the second evacuation port 400.

Embodiment 2

As shown in FIG. 2, the furnace tube apparatus in this embodiment has substantially the same structure as the structure in embodiment 1, except that the furnace tube apparatus in this embodiment further comprises a substantially cylindrical manifold 500 connected to the bottom ends of the inner tube 100 and the outer tube 200, with all side surfaces (as shown in FIG. 2) or part of side surfaces (not shown) exposed and not covered by the outer tube 200. The manifold 500 is in communication with the process space S1 and is not in communication with the gap region S2. The first evacuation port 300 is disposed on the manifold 500 and is in communication with the process space S1, and the second evacuation port 400 remains in the position above the first evacuation port 300.

Disposing the first evacuation port 300 on the manifold 500 (e.g., on the side surface) is beneficial to reducing the processing difficulty of the inner tube 100 and the outer tube 200 while ensuring evacuation efficiency, compared with disposing the first evacuation port 300 on the inner tube 100 through the outer tube 200 and the gap region S2. Moreover, the manifold 500 is usually made of metal, and disposing the first evacuation port 300 on the manifold 500 also reduces the processing difficulty of the first evacuation port 300.

In this embodiment, the material of the first evacuation port 300 is the same as the material of the manifold 500. The first evacuation port 300 and the manifold 500 are processed separately and then welded together to form an integral unit.

In some embodiments, the first evacuation port 300 and the manifold 500 may also be integrally formed, which can avoid welding defects and potential leakage problem at the joint.

Embodiment 3

As shown in FIG. 3, the furnace tube apparatus in this embodiment has substantially the same structure as the structure in embodiment 2, except that in this embodiment, the manifold 500 includes a first region S3 and a second region S4 which are not connected to each other. The first region S3 is in communication with the process space S1, and the second region S4 is in communication with the gap region S2. The first evacuation port 300 is disposed on the manifold 500 and is in communication with the first region S3. The second evacuation port 400 is disposed on the manifold 500 and is in communication with the second region S4.

Compared with the solution in embodiment 2, this solution also disposes the second evacuation port 400 on the manifold 500. While ensuring evacuation efficiency, the processing difficulty of the second evacuation port 400 is reduced, and the processing difficulty of the inner tube 100 and the outer tube 200 is also reduced. In addition, the first evacuation port 300 and the second evacuation port 400 do not need to be disposed on the inner tube 100 and the outer tube 200, which reduces processing defects of the inner tube 100 and the outer tube 200 and improves the overall sealing performance of the furnace tube apparatus.

In some embodiments, the first region S3 and the second region S4 may also be provided with a communication opening.

Specifically, the manifold 500 includes a first pipe member 510 and a second pipe member 520. One end of the second pipe member 520 is connected to the inner tube 100 and the outer tube 200, and the other end of the second pipe member 520 is connected to the first pipe member 510. The first pipe member 510 is a substantially cylindrical single-layer structure, and the second pipe member 520 is a double-layer structure with a hollow interlayer. The first region S3 is a region enclosed by the inner layer of the second pipe member 520 and the first pipe member 510 together, and the second region S4 is the hollow interlayer region of the second pipe member 520. The

lateral dimension of the inner layer of the second pipe member 520 is smaller than the lateral dimension of the first pipe member 510, with a step therebetween. The first evacuation port 300 is disposed on the first pipe member 510, and the second evacuation port 400 is disposed on the second pipe member 520. A communication opening 600 is provided at the bottom end of the gap region S2 between the inner tube 100 and the outer tube 200, and the second region S4 is in communication with the gap region S2 through the communication opening 600. By providing the communication opening 600 and modifying the structure of the manifold 500, the second evacuation port 400 can be disposed on the manifold 500.

In this embodiment, the materials of the first evacuation port 300, the second evacuation port 400, and the manifold 500 are the same, all being metal materials such as stainless steel.

In this embodiment, the first evacuation port 300, the second evacuation port 400, and the manifold 500 are processed separately and then welded together to form an integral unit.

In some embodiments, the first evacuation port 300, the second evacuation port 400, and the manifold 500 are integrally formed.

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

What is claimed is:

1. A furnace tube apparatus, comprising:

an inner tube, forming a process space inside the inner tube;

an outer tube, sleeved outside the inner tube, a gap region being present between the outer tube and the inner tube, and the inner tube being provided with an exhaust port to connect the process space and the gap region;

a first evacuation port, connected to the process space;

a second evacuation port, connected to the gap region.

2. The furnace tube apparatus according to claim 1, wherein the first evacuation port passes through the outer tube and the gap region and is disposed on the inner tube, and the second evacuation port is disposed on the outer tube.

3. The furnace tube apparatus according to claim 1, wherein the material of the first evacuation port is the same as the material of the inner tube, and/or the material of the second evacuation port is the same as the material of the outer tube.

4. The furnace tube apparatus according to claim 1, wherein the furnace tube apparatus further comprises a heating assembly disposed outside the outer tube, and the first evacuation port and the second evacuation port are located below the heating assembly and are at the same height.

5. The furnace tube apparatus according to claim 1, wherein the furnace tube apparatus further comprises a manifold connected to the bottom ends of the inner tube and the outer tube, the manifold is in communication with the process space and is not in communication with the gap region, the first evacuation port is disposed on the manifold, and the second evacuation port is disposed on the outer tube.

6. The furnace tube apparatus according to claim 5, wherein the material of the first evacuation port is the same as the material of the manifold, and/or the material of the second evacuation port is the same as the material of the outer tube.

7. The furnace tube apparatus according to claim 1, wherein the furnace tube apparatus further comprises a manifold connected to the bottom ends of the inner tube and the outer tube, the manifold includes a first region and a second region, the first region is in communication with the process space, the second region is in communication with the gap region, the first evacuation port is disposed on the manifold and is in communication with the first region, and the second evacuation port is disposed on the manifold and is in communication with the second region.

8. The furnace tube apparatus according to claim 7, wherein the manifold includes a first pipe member and a second pipe member, one end of the second pipe member is connected to the inner tube and the outer tube, the other end of the second pipe member is connected to the first pipe member, the second pipe member is a double-layer structure with a hollow interlayer, the first region is a region enclosed by the inner layer of the second pipe member and the first pipe member together, and the second region is the hollow interlayer region of the second pipe member; the first evacuation port is disposed on the first pipe member, and the second evacuation port is disposed on the second pipe member.

9. The furnace tube apparatus according to claim 7, wherein the materials of the first evacuation port and the second evacuation port are the same as the material of the manifold.

10. The furnace tube apparatus according to any one of claims 1, 5, and 7, wherein the furnace tube apparatus further comprises at least two evacuation pumps, and the evacuation pumps are respectively connected to the first evacuation port and the second evacuation port.

11. The furnace tube apparatus according to any one of claims 1, 5, and 7, wherein the aperture of the first evacuation port is larger than the aperture of the second evacuation port.