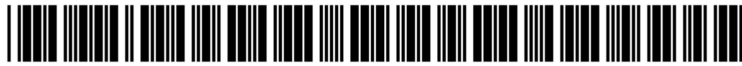

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(54) **POWDER ATOMIC LAYER DEPOSITION EQUIPMENT WITH QUICK RELEASE FUNCTION**

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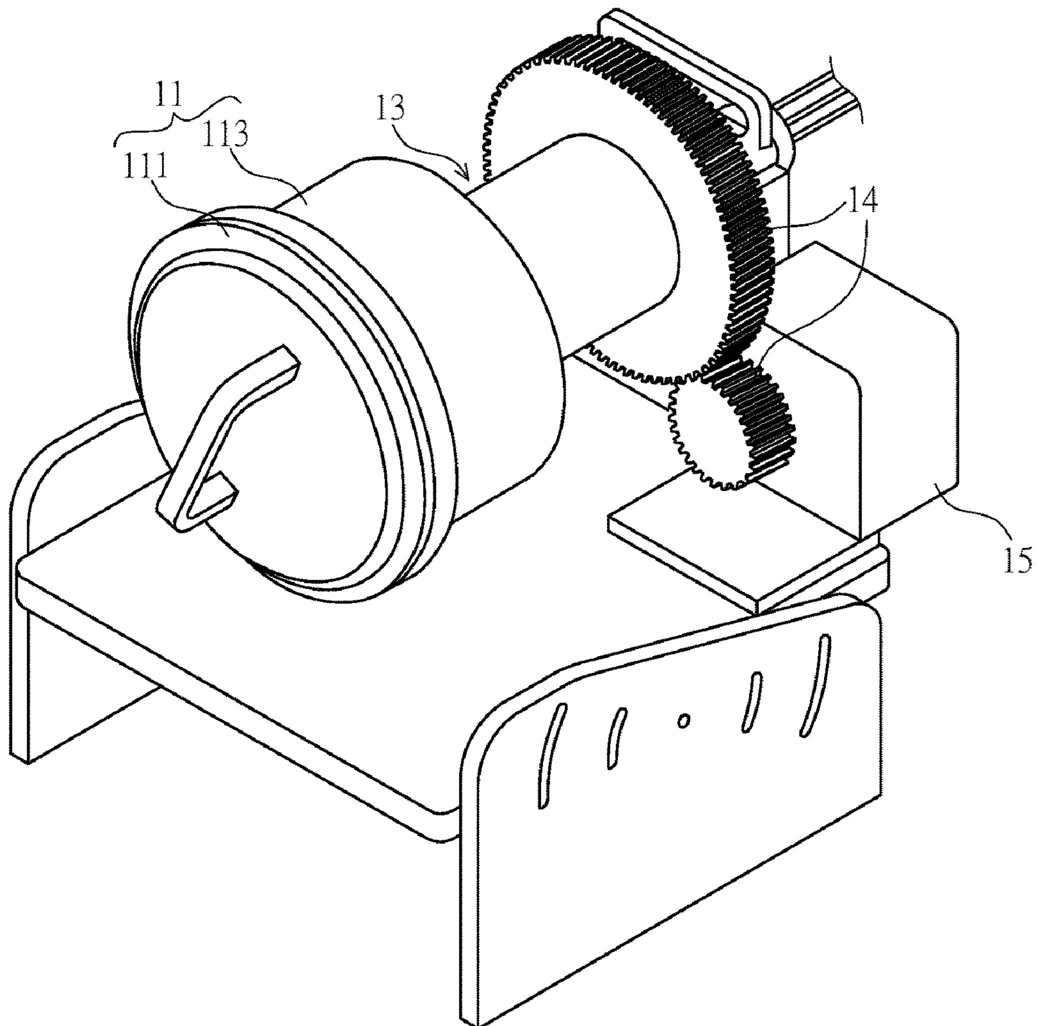
(57) **ABSTRACT**

Disclosed is a powder atomic layer deposition equipment with a quick release function, comprising a vacuum chamber, a shaft sealing device, and a driving unit connected to the shaft sealing device. The vacuum chamber is connected to the shaft sealing device, and an enclosed space is formed between the vacuum chamber and the shaft sealing device. At least one air extraction line is located in the shaft sealing device and fluidly connected to the enclosed space, the air extraction line being used in pumping gas out from the enclosed space to fix the vacuum chamber to the shaft sealing device so that the drive unit rotates the vacuum chamber via the shaft sealing device to facilitate the formation of a uniform thin film on powder surface. When the pumping stops, the vacuum chamber can be quickly released from the shaft sealing device to improve the process efficiency and convenience of use.



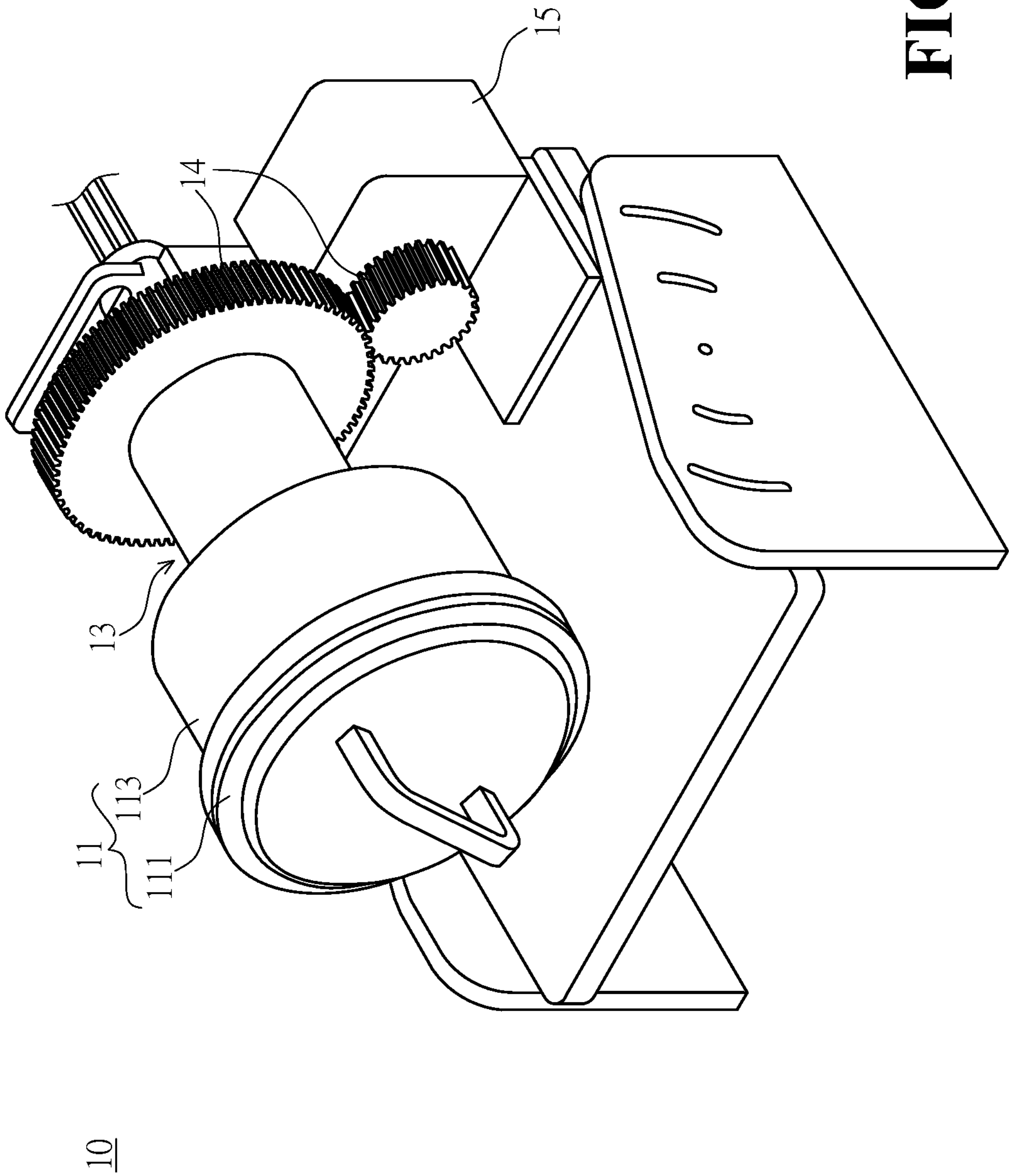


FIG. 1

FIG. 2

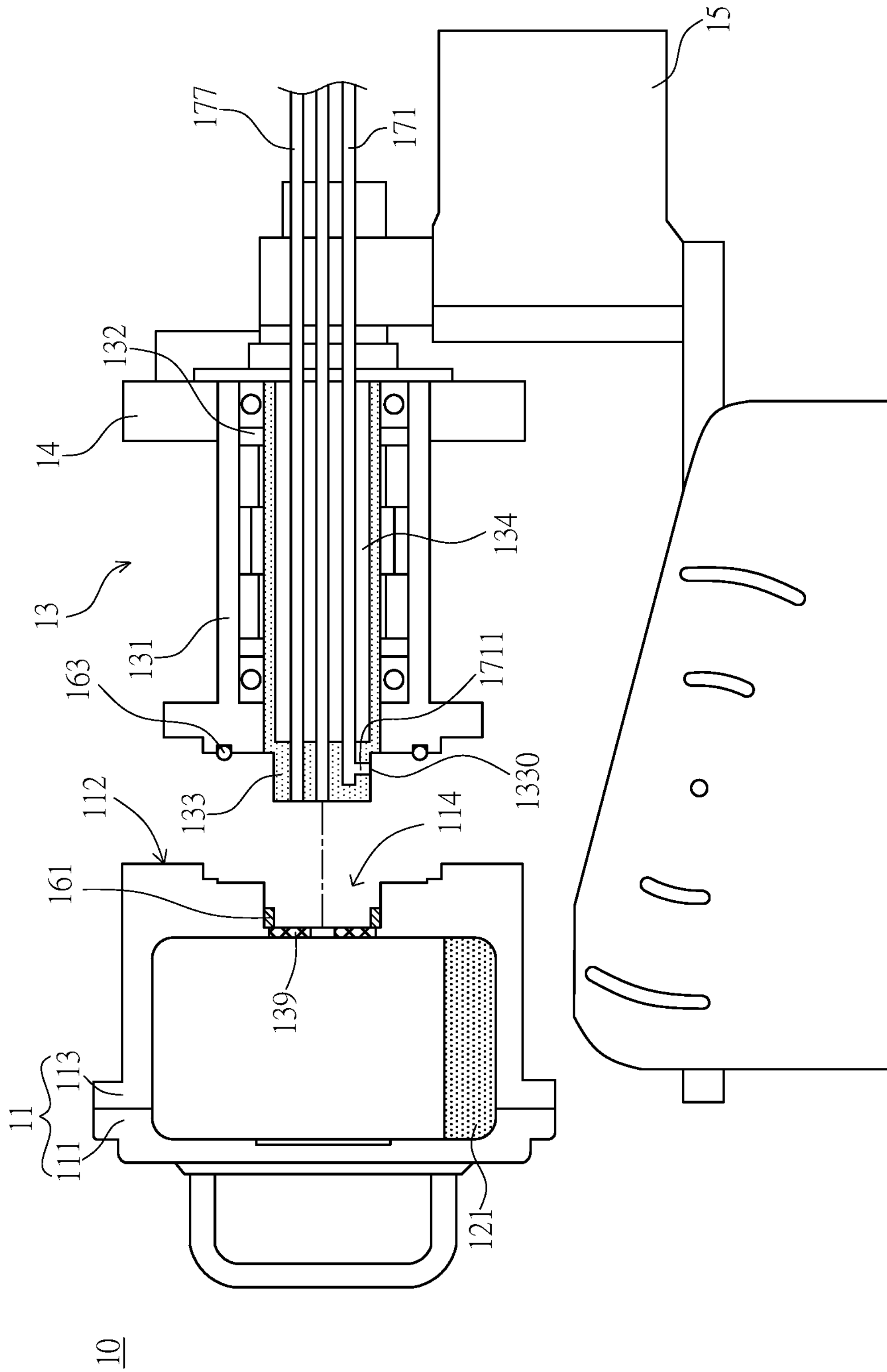


FIG. 3

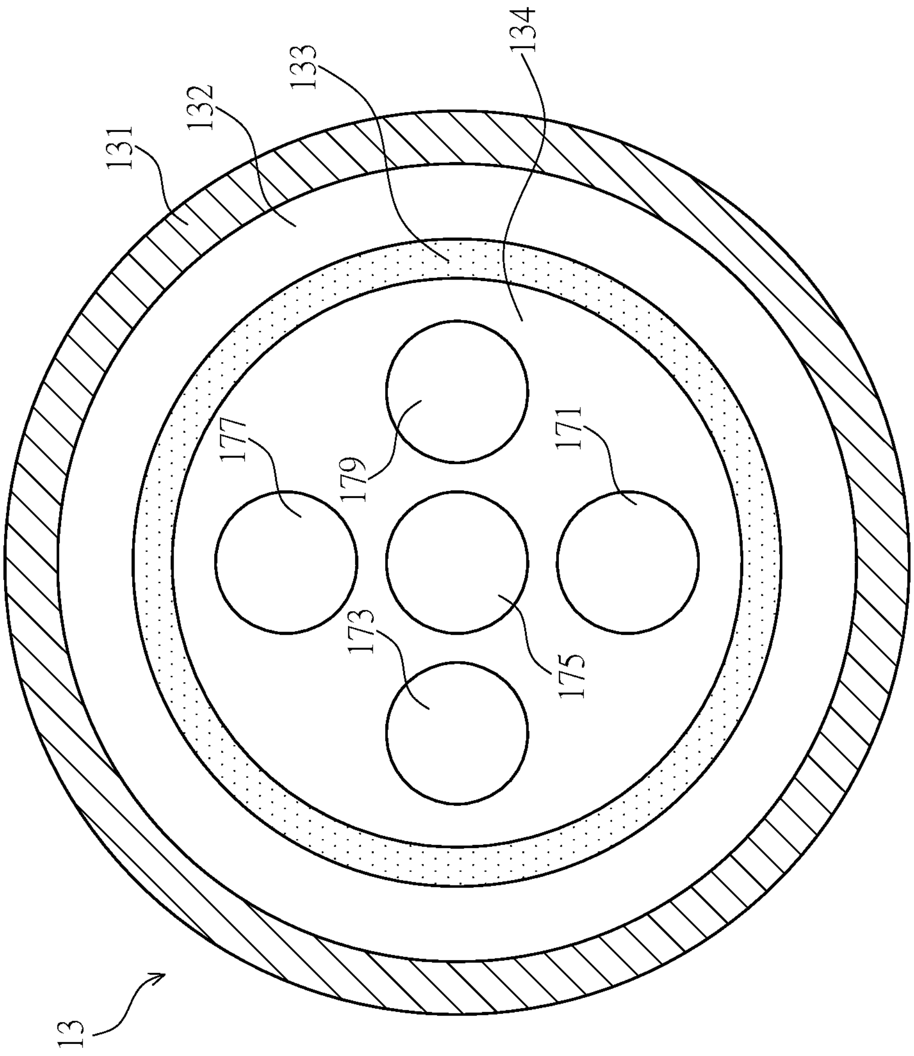


FIG. 4

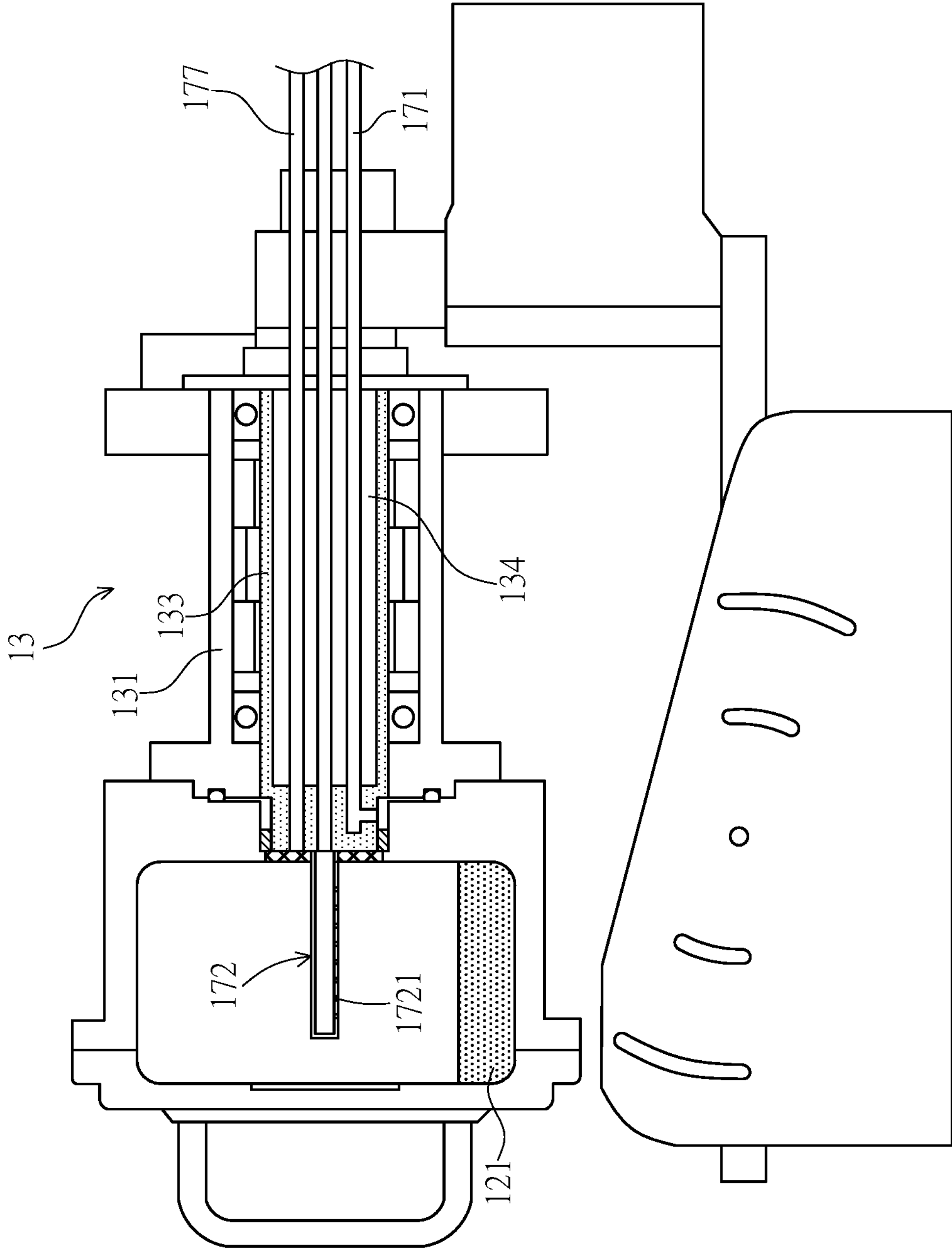


FIG. 5

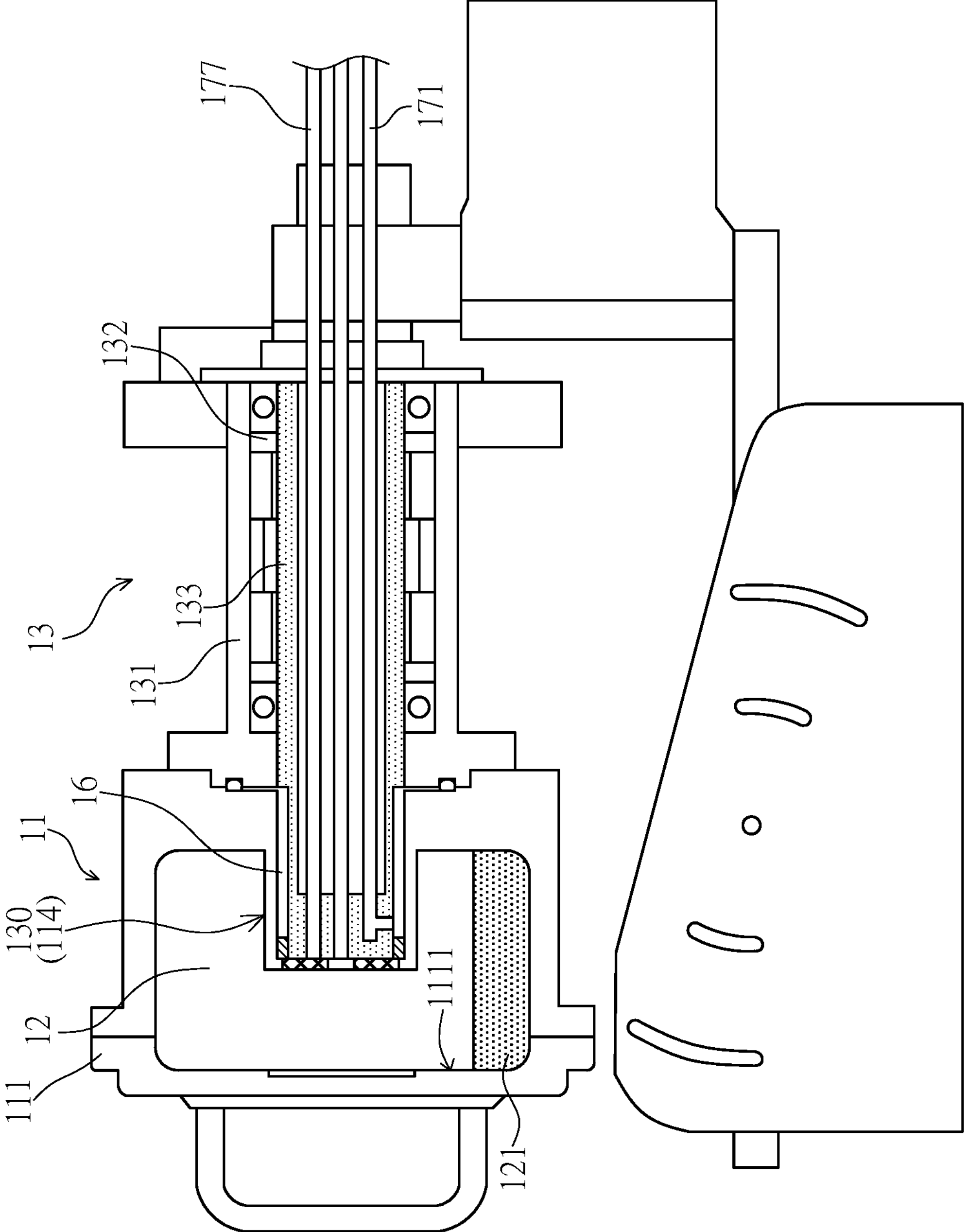


FIG. 6

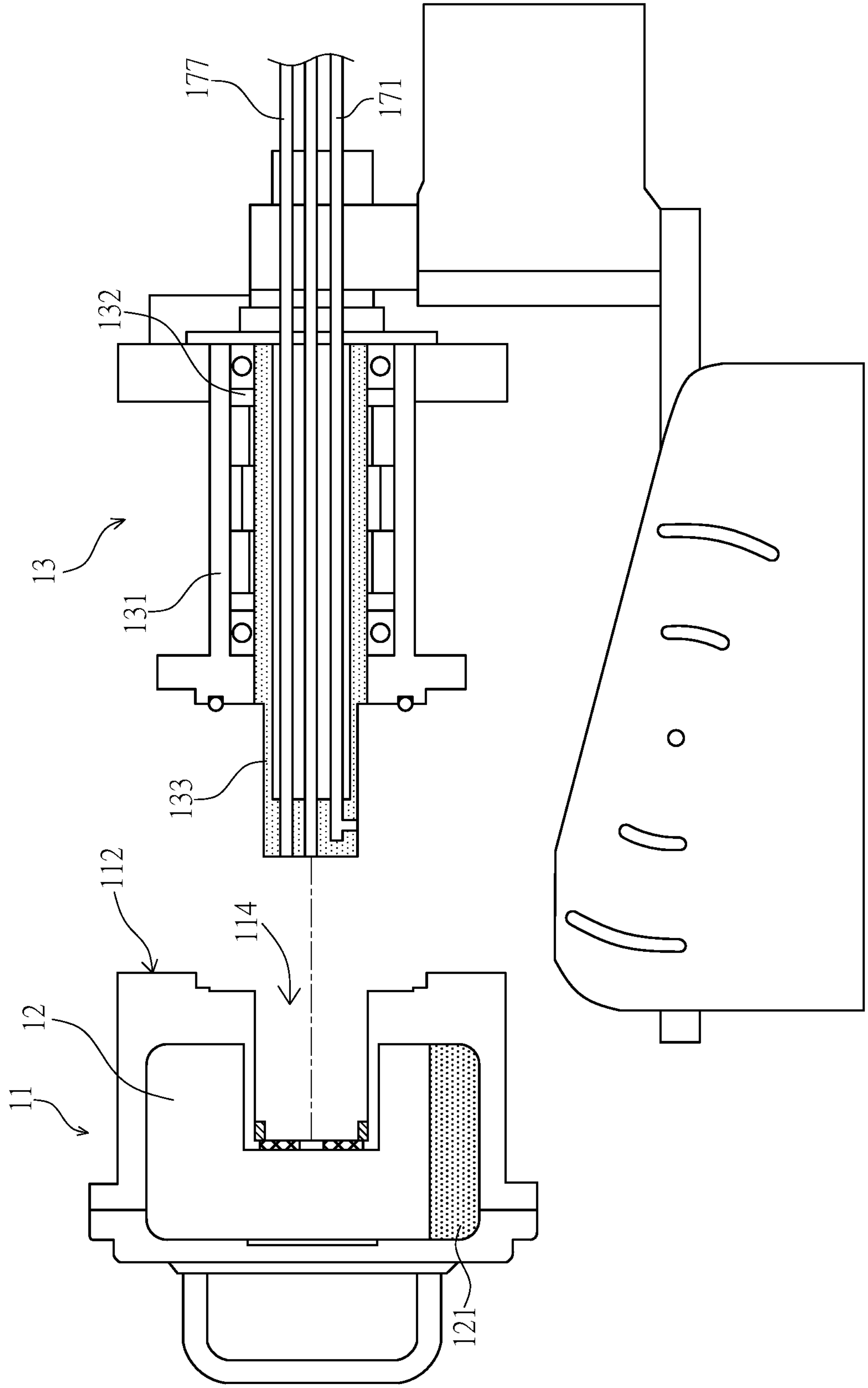


FIG. 7

POWDER ATOMIC LAYER DEPOSITION EQUIPMENT WITH QUICK RELEASE FUNCTION

TECHNICAL FIELD

[0001] The present disclosure relates to a powder atomic layer deposition equipment with a quick release function which allows fixing a vacuum chamber to a shaft sealing device, and a quick release of the vacuum chamber from the shaft sealing device.

BACKGROUND

[0002] A nanoparticle is defined as a particle smaller than 100 nanometer (nm) in at least one dimension, which shows entirely different physical and chemical properties comparing with that in macroscopic scale. Generally, macroscopic matters have all the same physical property, no matter what size they are, however neither do the nanoparticles. Nanoparticles have potential applications in the fields of biomedicine, optics and electronics, etc.

[0003] Quantum dots are nanoparticles of a semiconductor material. Currently studied semiconductor materials are II-VI materials, such as zinc sulfide (ZnS), cadmium sulfide (CdS) and cadmium selenide (CdSe), among which Cdse receives the most attention. The size of quantum dots is generally between 2-50 nm, and when quantum dots are exposed to UV light, electrons in the quantum dots absorb energy and jump from valence band into conduction band. When the excited electrons fall from conduction band to valence band, energy is released by emitting light.

[0004] The energy gap of quantum dots is related to the size. Larger quantum dots have smaller energy gap and emit light with longer wavelength. Smaller quantum dots have larger energy gap and emit light with shorter wavelength. For example, quantum dots having a size of 5-6 nm emit orange or red light, quantum dots having a size of 2-3 nm emits blue or green light. Of course, the light color also depends on the material of quantum dots.

[0005] A light-emitting diode (LED) employing quantum dots generates light with both a nearly continuous spectrum and a high color-rendering index, which is advantageous in improving the quality of light for the LED. In addition, the wavelength of the emitted light can be adjusted by changing the size of the quantum dots. Therefore, Quantum dots become the focus of the development of new-generation light-emitting devices and displays.

[0006] Although quantum dots possess the advantages and characteristics as described above, agglomeration is prone to occur in the process of manufacture or application. Moreover, quantum dots have a higher surface activity, and react with air and water vapor easily, thereby shortening their service life.

[0007] In particular, when making quantum dots into an LED sealant, agglomeration effect may occur, reducing the optical performance of quantum dots. Further, after the quantum dots are made into an LED sealant, oxygen or water vapor may still penetrate through the sealant and contact the surface of quantum dots, causing oxidation of the quantum dots, thereby affecting the efficiency or service life of quantum dots and LEDs. On the other hand, defects and dangling bonds on the surface of the quantum dots may cause non-radiative recombination, which also affects the emitting efficiency of quantum dots.

[0008] At present, the industry mainly employs powder atomic layer deposition (ALD) to form a nanometer-thick film on the surface of quantum dots, or form a multilayer film on the surface of quantum dots as a quantum well structure.

[0009] Atomic layer deposition can form a thin film with uniform thickness on the substrate, and the thickness of the thin film can be effectively controlled. Theoretically, it is also suitable for three-dimensional quantum dots. When the quantum dots are placed on the carrier plate, contact points exist between adjacent quantum dots, so that the precursor gas in an atomic layer deposition process cannot reach these contact points, causing failure in forming a uniform film on the surface of all nanoparticles.

SUMMARY

[0010] In general, atomic layer deposition is required to be performed in a vacuum environment. Therefore, equipments for atomic layer deposition often have a thicker structure with considerable weight, making it difficult in transportation or operation by a user. In view of the above, the present invention provides a powder atomic layer deposition equipment with a quick release function, wherein a vacuum chamber can be quickly released from a shaft sealing device and/or a driving unit after an atomic layer deposition process, allowing a user to easily take out powders from the vacuum chamber and clean the vacuum chamber.

[0011] An object of the present disclosure is to provide a powder atomic layer deposition equipment with a quick release function, which mainly comprises a driving unit, a shaft sealing device, and vacuum chamber, wherein the driving unit may be connected to the shaft sealing device or be released from the shaft sealing device, allowing a user to easily take out powders from the vacuum chamber and clean the vacuum chamber and thus improving convenience of use.

[0012] An object of the present disclosure is to provide a powder atomic layer deposition equipment with a quick release function, which mainly utilizes an air extraction line to control a connection state between a shaft sealing device and a vacuum chamber, getting rid of the complexity of fixing the vacuum chamber and the shaft sealing device by screws. The convenience of release or installation of the vacuum chamber onto the shaft sealing device can also be greatly improved.

[0013] An object of the present disclosure is to provide a powder atomic layer deposition equipment with a quick release function, allowing a vacuum chamber with powders to be released from a shaft sealing device after an atomic layer deposition process has been done, and another vacuum chamber with powders loaded to be fixed to the shaft sealing device to perform a powder atomic layer deposition, thereby improving the efficiency of the manufacturing process.

[0014] To achieve the abovementioned objects, the present disclosure provides a powder atomic layer deposition equipment with a quick release function, comprising a driving unit; a shaft sealing device connected to the driving unit; a vacuum chamber connected to the shaft sealing device, and an enclosed space is formed between the shaft sealing device and the vacuum chamber, wherein the vacuum chamber includes a reaction space for accommodating a plurality of powders, and the driving unit rotates the vacuum chamber via the shaft sealing device; at least one first seal ring and at least one second seal ring, located between the shaft sealing

device and the vacuum chamber, wherein the enclosed space is located between the first seal ring and the second seal ring; at least one first air extraction line, located in the shaft sealing device and fluidly connected to the enclosed space, wherein the first air extraction line is used in pumping gas out from the enclosed space to fix the vacuum chamber to the shaft sealing device; and at least one air intake line, located in the shaft sealing device and fluidly connected to the reaction space of the vacuum chamber, for delivering a precursor gas into the reaction space.

[0015] The powder atomic layer deposition equipment with a quick release function, comprising a second air extraction line located in the shaft sealing device and fluidly connected to the reaction space of the vacuum chamber.

[0016] The powder atomic layer deposition equipment with a quick release function, wherein the shaft sealing device comprises an outer tube and an inner tube, the outer tube including an accommodating space for accommodating the inner tube, and the inner tube including at least one connecting space for accommodating the first air extraction line and the air intake line.

[0017] The powder atomic layer deposition equipment with a quick release function, wherein the first seal ring is located between the inner tube and the vacuum chamber, and the second seal ring is located between the outer tube and the vacuum. The first seal ring is a dynamic seal ring, and the second seal ring is a static seal ring.

[0018] The powder atomic layer deposition equipment with a quick release function, wherein the driving unit is connected to the vacuum chamber via the outer tube, and rotates the vacuum chamber.

[0019] The powder atomic layer deposition equipment with a quick release function, wherein the vacuum chamber comprises a recessed part located at a bottom of the vacuum chamber. The recessed part is used for accommodating part of the inner tube protruding from the shaft sealing device, with an enclosed space formed between the inner tube and the recessed part of the vacuum chamber.

[0020] The powder atomic layer deposition equipment with a quick release function, wherein the recessed part extends from the bottom of the vacuum chamber to the reaction space and forms a protruding tubular part.

[0021] The powder atomic layer deposition equipment with a quick release function, further comprising a filter unit located in the recessed part of the vacuum chamber. In addition, the air intake line is fluidly connected to the reaction space of the vacuum chamber via the filter unit.

[0022] The powder atomic layer deposition equipment with a quick release function, wherein the air intake line is used in delivering a non-reactive gas into the reaction space to blow the powders in the reaction space.

[0023] The powder atomic layer deposition equipment with a quick release function, wherein the air intake line includes at least one non-reactive gas delivering pipeline, located in the shaft sealing device and fluidly connected to the reaction space of the vacuum chamber. The non-reactive gas delivering pipeline is used in delivering a non-reactive gas into the reaction space to blow the powders in the reaction space.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The structure as well as preferred modes of use, further objects, and advantages of this present disclosure will be best understood by referring to the following detailed description of some illustrative embodiments in conjunction with the accompanying drawings, in which:

[0025] FIG. **1** is a perspective view illustrating a powder atomic layer deposition equipment with a quick release function according to one embodiment of the present invention.

[0026] FIG. **2** is a sectional view of a powder atomic layer deposition equipment with a quick release function according to one embodiment of the present invention.

[0027] FIG. **3** is another sectional view of a powder atomic layer deposition equipment with a quick release function according to one embodiment of the present invention.

[0028] FIG. **4** is a sectional view of a powder atomic layer deposition equipment with a quick release function according to one embodiment of the present invention.

[0029] FIG. **5** is a sectional view of a powder atomic layer deposition equipment with a quick release function according to another embodiment of the present invention.

[0030] FIG. **6** is a sectional view of a powder atomic layer deposition equipment with a quick release function according to another embodiment of the present invention.

[0031] FIG. **7** is another sectional view of a powder atomic layer deposition equipment with a quick release function according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0032] Please refer to FIG. **1**, FIG. **2**, FIG. **3** and FIG. **4**, illustrating a powder atomic layer deposition equipment with a quick release function according to one embodiment of the present invention. As shown in the figures, a powder atomic layer deposition equipment with a quick release function **10** mainly comprises a vacuum chamber **11**, a shaft sealing device **13**, and a driving unit **15**, wherein the driving unit **15** is connected to the vacuum chamber **11** via the shaft sealing device **13** and rotates vacuum chamber **11**.

[0033] The vacuum chamber **11** has a reaction space **12** inside, for accommodating a plurality of powders **121**, wherein the powders **121** may be quantum dots, for example, II-VI semiconductor materials of ZnS, CdS, CdSe, etc. The thin film formed on the quantum dots may be of Al_2O_3. The vacuum chamber may include a cover plate **111** and a chamber **113**, wherein an inner surface **1111** of the cover plate **111** is used to cover the chamber **113** and forms a reaction space **12** between the inner surface **1111** and the chamber **113**.

[0034] In one embodiment of the present invention, a monitoring wafer **115** may be configured on the inner surface **1111** of the cover **111** plate, wherein when the cover plate **111** covers the chamber **113**, the monitoring wafer **115** is located in the reaction space **12**. When an atomic layer deposition is performed in the reaction space **12**, a thin film is formed on a surface of the monitoring wafer. In practical applications, the film thickness on the surface of the monitoring wafer **115** and the film thickness on the surface of the powders **121** may be further measured, and the relationship between the two may be calculated. Then, the film thickness on the surface of the monitoring wafer **115** may be measured to calculate the film thickness on the surface of the powders **121**.

[0035] The shaft sealing device comprises an outer tube **131** and an inner tube **133**, wherein the outer tube **131** has an accommodating space **132**, and the inner tube **133** has a connecting space **134**. For example, the outer tube **131** and

the inner tube **133** may be hollow cylinders. The accommodating space **132** of the outer tube **131** may accommodate the inner tube **133**, wherein the outer tube **131** and the inner tube **133** are coaxially disposed. The shaft sealing device may be a common shaft seal or magnetic fluid shaft seal, and is mainly used in isolating the reaction space **12** of the vacuum chamber **11** from an exterior space to maintain the vacuum of the reaction space **12**.

[0036] The driving unit **15** is connected to one end of the shaft sealing device, and rotates the vacuum chamber **11** via the shaft sealing device **13**. For example, the driving unit **15** is connected to the vacuum chamber **13** via the outer tube **131**, and rotates the vacuum chamber **11** via the outer tube **131**.

[0037] The driving unit **15** may be connected to and rotate the outer tube **131** and the vacuum chamber **11** in a same direction, for example, a continuous clockwise or counterclockwise rotation. In certain other embodiments, the driving unit **15** may rotate the outer tube **131** and the vacuum chamber **11** clockwise for a specific angle, followed by a counterclockwise rotation of the specific angle. For example, the specific angle may be 360°. When the vacuum chamber **11** rotates, it stirs the powders **121** in the reaction space **12** to facilitate a uniform heating of the powders **121** and their contact with a precursor gas or a non-reactive gas.

[0038] In one embodiment of the present invention, the driving unit **15** may be a motor, connected to the outer tube **131** via at least one gear **14**, and rotate the outer tube **131** and the vacuum chamber **11** via the gear **14** with respect to the inner tube **133**.

[0039] The connecting space **134** of the inner tube **133** may be configured with at least one first air extraction line **171**, at least one air intake line **173**, at least one non-reactive gas delivering pipeline **175**, a heater **177**, and/or a second air extraction line **179**, as shown in FIG. **2** and FIG. **4**.

[0040] The vacuum chamber **11** and the shaft sealing device of the present invention are two independent components, wherein the vacuum chamber **11** may be released/dismounted from the shaft sealing device **13**, or be fixed to the shaft sealing device. When the vacuum chamber **11** is connected to the shaft sealing device **13**, an enclosed space **16** is formed between the two. For example, the enclosed space **16** may be ring-shaped and surround the shaft sealing device **13**. The first air extraction line **171** is fluidly connected to the enclosed space **16** and is used in pumping gas out from the enclosed space **16**, or in delivering gas into the enclosed space **16**.

[0041] The second air extraction line **179** is fluidly connected to the reaction space **12** of the vacuum chamber **11**, and is used in pumping gas out from the reaction space **12**, such that the reaction space **12** is in a vacuum state for an atomic layer deposition process. Specifically, the second air extraction line **179** is connected to a pump, and gas in the reaction space **12** is pumped out by the pump.

[0042] The air intake line **173** is fluidly connected to the reaction space **12** of the vacuum chamber **11**, and is used in delivering a precursor gas or a non-reactive gas into the reaction space **12**, wherein the non-reactive gas may be an inert gas such as nitrogen or argon. For example, the air intake line **173** may be connected to a precursor gas storage tank and a non-reactive gas storage tank via a valve element, and deliver the precursor gas into the reaction space **12** to deposit the precursor gas on the surface of the powders **121**. In practical application, the air intake line may deliver the precursor gas along with a carrier gas into the reaction space **12**. Subsequently, the non-reactive gas is delivered into the reaction space **12** by the valve element, and gas is pumped out via the second air extraction line **179** to remove the precursor gas in the reaction space **12**. In one embodiment of the present invention, the air intake line **173** may be connected to a plurality of branches, and sequentially deliver different precursor gases into the reaction space **12** via the plurality of branches, respectively.

[0043] Further, the flow rate of the non-reactive gas delivered by the air intake line **173** may be increased, and blow the powders **121** in the reaction space by the non-reactive gas, such that the powders **121** is moved by the non-reactive gas and spread to various areas of the reaction space **12**.

[0044] In one embodiment of the present invention, the air intake line **173** may include at least one non-reactive gas delivering pipeline **175**, connected to the reaction space **12** of the vacuum chamber **11**, and is used in delivering a non-reactive gas into the reaction space **12**. For example, the non-reactive gas delivering pipeline **175** may be connected to a nitrogen storage tank via a valve element, and deliver nitrogen into the reaction space **12** via the valve element. The non-reactive gas which is used to blow and move the powders **121** in the reaction space **12**, cooperating with the driving unit **15** which rotates the vacuum chamber **11**, can effectively and uniformly stir the powders **121** in the reaction space **12** and uniform thin film can be deposited on the surface of each powders **121**.

[0045] Both the air intake line **173** and the non-reactive gas delivering line **175** of the powder atomic layer deposition equipment with a quick release function **10** are used in delivering a non-reactive gas into the reaction space **12**, wherein a flow rate of the non-reactive gas delivered by the air intake line **173** is lower, mainly useful in removing a precursor gas in the reaction space **12**, and a flow rate of the non-reactive gas delivered by the non-reactive gas delivering line **175** is higher, mainly useful in blowing and moving the powders **121** in the reaction space **12**.

[0046] Specifically, the air intake line **173** and the non-reactive gas delivering line **175** deliver the non-reactive gas into the reaction space **12** at different time points. Therefore, in practical applications, the non-reactive gas delivering line **175** may be omitted, and the flow rate of the non-reactive gas delivered by the air intake line **173** at different time points may be adjusted. In removing a precursor gas in the reaction space **12**, the flow rate of the non-reactive gas delivered by the air intake line **173** into the reaction space **12** may be decreased, while in blowing and moving the powders **121** in the reaction space **12**, the flow rate of the non-reactive gas delivered by the air intake line **173** into the reaction space **12** may be increased.

[0047] When the driving unit **15** of the present invention rotates the outer tube **131** and the vacuum chamber **11**, the inner tube **133** and the first air extraction line **171**, second air extraction line **179**, the air intake line **173**, and/or the non-reactive gas delivering pipeline **175** therein are not rotated. This is beneficial to increasing the stability of delivery of non-reactive gas and/or precursor gas by the air intake line **173** and/or the non-reactive gas delivering pipeline **175** into the reaction space **12**.

[0048] A heater **177** is used to heat the connecting space **134** and the inner tube **133**, and the second air extraction line **179**, the air intake line **173** and/or the non-reactive gas delivering pipeline **175** in the inner tube **133** are heated by

the heater **177**, to increase the temperature of gas in the second air extraction line **179**, the air intake line **173** and/or the non-reactive gas delivering pipeline **175**. As such, when non-reactive gases and/or precursor gases enter the reaction space **12**, the temperature of the reaction space **12** does not drop or change significantly. In addition, a temperature sensing unit may be configured in the connecting space **134** to measure the temperature of the heater **177** or the connecting space **134** so as to retrieve information on a work status of the heater **177**. Of course, another heating device is usually configured inside, outside or around the vacuum chamber **11**, wherein the heating device is adjacent or in contact with the vacuum chamber **11** and is used in heating the vacuum chamber and the reaction space **12**.

[0049] When performing an atomic layer deposition process, the reaction space **12** of the vacuum chamber **11** is required to maintain in a vacuum state, and thus the vacuum chamber **11** usually has a thicker structure and a heavier weight. The shaft sealing **13** is used to support and rotate the vacuum chamber **11** and also has a thicker structure and a heavier weight. In operation a use needs to release/dismount the vacuum chamber **11** from the driving unit **15** along with the shaft sealing device **13** in order to take out the powders **121** in the vacuum chamber **11** and clean the vacuum chamber **11**. This not only causes a burden on the user, but also may cause a collision during operation and cleaning, which may result in injury to the user or damage to the equipment.

[0050] To address the above problem, the vacuum chamber **11** and the shaft sealing device **13** of the present invention are designed as two independent components. In performing an atomic layer deposition, the vacuum chamber **11** may be connected to the shaft sealing device **13** as shown in FIG. **2**, forming an enclosed space **16** between the vacuum chamber **11** and the shaft sealing device **13**. Then the gas in the enclosed space **16** is pumped out via the first air extraction line **171** such that the enclosed space **16** is in a vacuum state, to fix the vacuum chamber **11** to the shaft sealing device **13**. Further, the driving unit **15** can rotate the vacuum chamber **11** via the shaft sealing device **13**. When the vacuum chamber **11** is connected to the shaft sealing device **13**, the second air extraction line **179**, the air intake line **173** and/or the non-reactive gas delivering pipeline is fluidly connect to the reaction space **12** of the vacuum chamber **11**.

[0051] After the atomic layer deposition has been done, the vacuum of the enclosed space **16** may be released via the first air extraction line **171**. For example, delivering gas via the first air extraction line **171** into the enclosed space **16** to release/dismount the vacuum chamber **11** from the shaft sealing device **13**.

[0052] In the powder atomic layer deposition equipment with a quick release function **10** of the present invention, the vacuum chamber **11** can be quickly released/dismounted from the shaft sealing device **13**, and another vacuum chamber **11** can be installed to the shaft sealing device **13**. In the process of releasing and installing vacuum chambers **11**, it is only required to pump gas out from the enclosed space **16** via the first air extraction line **171** by a pump, or to deliver gas into the enclosed space **16** via the first pumping line **171**, while fixing the vacuum chamber **11** and the shaft sealing device **13** by screws is not required, thereby greatly improving the speed and convenience of replacing the vacuum chamber **11**.

[0053] In one embodiment of the present invention, a plurality of seal rings may be disposed between the shaft sealing device **13** and the vacuum chamber **11**, wherein the enclosed space **16** is located between two seal rings, and the enclosed space **16** is isolated from an exterior space by the seal rings. Specifically, the seal rings include a first seal ring **161** and a second seal ring **163**. When the vacuum chamber **13** is connected to the shaft sealing device **13**, the vacuum chamber **11** and the shaft sealing device **13** press the first seal ring **161** and the second seal ring **163** therebetween, and the enclosed space **16** is formed between the first seal ring **161** and the second seal ring **163**. As shown in FIG. **3**, the first seal ring **161** is configured on the vacuum chamber **11**, and the second seal ring is configured on the shaft sealing device **13**.

[0054] In practical applications, the first seal ring **161** is disposed between the inner tube **133** and the vacuum chamber **11**, and the second seal ring **163** is disposed between the outer tube **131** and the vacuum chamber **11**, wherein the first seal ring **161** is a dynamic seal ring, and the second seal ring **163** is a static seal ring. For example, the first seal ring **161** may be sleeved on the inner tube **133** and is a PTFE O-ring, and the second seal ring **163** is an O-ring made of a rubber.

[0055] In one embodiment of the present invention, as shown in FIG. **3**, a recessed part **114** may be configured on a bottom **112** of the vacuum chamber **11**, and the first seal ring **161** is disposed in the recessed part **114**. The inner tube **133** of the shaft sealing device partially protrudes from the outer tube **131**, and the second seal ring **163** is disposed at a side of the shaft sealing device **13** to which the bottom **112** of the vacuum chamber **11** is connected, or sleeved on a protruding part of the inner tube **133**.

[0056] The cross-sectional area in a radial direction of the inner tube **133** protruded from the shaft sealing device **13** is slight greater than that of the recessed part **114** of the vacuum chamber **11**. When the protruded inner tube **133** is inserted into the recessed part **114** of the vacuum chamber **11**, the protruded inner tube **133** presses the first seal ring **161** in the recessed part **114**, and the bottom **112** of the vacuum chamber **11** or the recessed part **114** presses the second seal ring **163** disposed on the shaft sealing device **13**, so as to form the enclosed space **16** between the protruded inner tube **133**, the recessed part **114**, the first seal ring **161**, and/or the second seal ring **163**. The above mentioned numbers and locations of configuration of the protruded inner tube **133**, the recessed part **114**, the first seal ring **161**, and/or the second seal ring **163** are only of one embodiment of the present invention, and the present invention is not limited thereto.

[0057] An opening **1330** is configured on a side wall the inner tube **133** of the shaft sealing device **13** of the present invention. The first air extraction line **171** is configured generally along an axial direction of the shaft sealing device **13** and has a branch **1711** branching or bending along a radial direction of the shaft sealing device **13**, and the branch **1711** is connected to the opening **1330** on the side wall of the inner tube **133**, such that the first air extraction line **171** is fluidly connected to the enclosed space **16** via the opening **1330** on the side wall of the inner tube **133**.

[0058] The powder atomic layer deposition equipment with a quick release function **10** as described in the present disclosure is also advantageous in improving the process efficiency of atomic layer deposition. Specifically, multiple vacuum chambers may be prepared and powders **121** may be

placed in each vacuum chamber **11**. One of the vacuum chambers **11** is fixed to the shaft sealing device **13**, and perform an atomic layer deposition on the powders **121** in the vacuum chamber **11**. After the atomic layer deposition has been done, the vacuum chamber **11** with powders **121** therein is released/dismounted from the shaft sealing device **13**, and another vacuum chamber **11** is fixed to the shaft sealing device **13** to perform an atomic layer deposition process on the powders **121** in the vacuum chamber **11**. The released vacuum chamber **11** may be placed in a cooling area, and the powders **121** are taken out from the vacuum chamber **11** after the temperature of the vacuum chamber **11** and powders **121** therein is decreased.

[0059] In one embodiment of the present invention, the bottom **112** of the vacuum chamber **11** may be configured with a filter unit **139**. For example, the filter unit **139** may be disposed in the recessed part **114** of the vacuum chamber **11**. When the vacuum chamber **11** is connected to the shaft sealing device **13**, the filter unit **139** on the vacuum chamber **11** covers the inner tube **133** of the shaft sealing device **13**, such that the second air extraction line **179**, air intake line **173**, and/or non-reactive gas delivering pipeline **175** is connected to the reaction space **12** of the vacuum chamber **11** via the filter unit **139**.

[0060] Through the configuration of the filter unit **139**, loss of powders **121** when gas is pumped out from the reaction space **12** via the second air extraction line **179** can be avoided. On the other hand, disposing on the filter unit **139** on the vacuum chamber **11** instead of on the shaft sealing device avoids that the powders **121** scatter out from the reaction space of the vacuum chamber **11** when the vacuum chamber **11** is released/dismounted from the shaft sealing device **13**.

[0061] In one embodiment of the present invention, as shown in FIG. **5**, the air intake line **173** and/or non-reactive gas delivering pipeline may extends from the connecting space **134** of the inner tube **133** to the reaction space **12** of the vacuum chamber **11**, and forms an extension tube **172** in the reaction space **12** of the vacuum chamber **11**. The extension tube **172** may be configured with at least one vent hole **1721** on a terminal part and/or a wall thereof. Non-reactive gas may be delivered to the reaction space **12** via the vent hole **1721** of the extension tube **172** to blow and move the powders **121** in the reaction space **12**.

[0062] In one embodiment of the present invention, the recessed part **114** may extend from the bottom **112** of the vacuum chamber **11** to the reaction space **12**, the inner tube **133** of the shaft sealing device **13** may extend from the accommodating space **132** of the outer tube **131** to an exterior and protrude from the outer tube **131** of the shaft sealing device **13**, as shown in FIG. **7**. To connect the vacuum chamber and the shaft sealing device, the protrude inner tube **133** of the shaft sealing device may be inserted into the recessed part **114**, and the enclosed space **16** is formed between the inner tube **133** and the recessed part **114** of the vacuum chamber **11**, as shown in FIG. **6**. Further, the inner tube **133** of the shaft sealing device extends from the accommodating space **132** of the outer tube to the recessed part **114** and/or reaction space **12** of the vacuum chamber **11**, such that the inner tube **133** and the recessed part form a protruding tubular part **130** in reaction space **12**.

[0063] Through the configuration of the protruding tubular part **13**, the distance between the air intake line **173** and/or the non-reactive gas delivering pipeline **175** and the cover plate **111** can be shortened or adjusted. Non-reactive gas delivered to the reaction space **12** via the air intake line **173** and/or the non-reactive gas delivering pipeline **175** can be transmitted to the inner surface **1111** of the cover plate **111**, and spread to various areas of the reaction space **12**, to facilitate blowing and moving the powders **121** in the reaction space **12**.

[0064] It should be understood that various changes and modifications to the presently preferred embodiments described herein will be apparent to those skilled in the art. Such changes and modifications can be made without departing from the spirit and scope of the present invention and without diminishing its intended advantages. It is therefore intended that such changes and modifications be covered by the appended claims.

We claim:

1. A powder atomic layer deposition equipment with a quick release function, comprising:

a driving unit;

a shaft sealing device connected to the driving unit;

a vacuum chamber connected to the shaft sealing device, and an enclosed space is formed between the vacuum chamber and the shaft sealing device, wherein the vacuum chamber includes a reaction space for accommodating a plurality of powders, and the driving unit rotates the vacuum chamber via the shaft sealing device;

at least one first seal ring and at least one second seal ring, located between the shaft sealing device and the vacuum chamber, wherein the enclosed space is located between the first seal ring and the second seal ring;

at least one first air extraction line, located in the shaft sealing device and fluidly connected to the enclosed space, wherein the first air extraction line is used in pumping gas out from the enclosed space to fix the vacuum chamber to the shaft sealing device; and

at least one air intake line, located in the shaft sealing device and fluidly connected to the reaction space of the vacuum chamber, for delivering a precursor gas into the reaction space.

2. The powder atomic layer deposition equipment with a quick release function according to claim **1**, comprising a second air extraction line located in the shaft sealing device and fluidly connected to the reaction space of the vacuum chamber.

3. The powder atomic layer deposition equipment with a quick release function according to claim **1**, wherein the shaft sealing device comprises an outer tube and an inner tube, the outer tube including an accommodating space for accommodating the inner tube, and the inner tube including at least one connecting space for accommodating the first air extraction line and the air intake line.

4. The powder atomic layer deposition equipment with a quick release function according to claim **3**, wherein the first seal ring is located between the inner tube and the vacuum chamber, and the second seal ring is located between the outer tube and the vacuum, the first seal ring being a dynamic seal ring and the second seal ring being a static seal ring.

5. The powder atomic layer deposition equipment with a quick release function according to claim **3**, wherein the first air extraction line is configured along an axial direction of

the inner tube and comprises a branch part, the first air extraction line being connected to the enclosed space via the branch part.

6. The powder atomic layer deposition equipment with a quick release function according to claim **5**, wherein the inner tube is configured with an opening on a side wall thereof, and the first air extraction line is connected to the enclosed space via the branch part and the opening.

7. The powder atomic layer deposition equipment with a quick release function according to claim **3**, comprising a heater located in the connecting space of the inner tube, and is used in heating the connecting space and the inner tube.

8. The powder atomic layer deposition equipment with a quick release function according to claim **3**, wherein the driving unit is connected to the vacuum chamber via the outer tube and rotates the vacuum chamber.

9. The powder atomic layer deposition equipment with a quick release function according to claim **3**, wherein the air intake line includes at least one non-reactive gas delivering pipeline, located in the connecting space of the inner tube and fluidly connected to the reaction space of the vacuum chamber, the non-reactive gas delivering pipeline being used in delivering a non-reactive gas into the reaction space to blow the powders in the reaction space.

10. The powder atomic layer deposition equipment with a quick release function according to claim **1**, wherein the shaft sealing device is a shaft seal or a magnetic fluid shaft seal.

11. The powder atomic layer deposition equipment with a quick release function according to claim **1**, wherein the air intake line is used in delivering a non-reactive gas into the reaction space, and the powders in the reaction space are moved by the non-reactive gas.

12. The powder atomic layer deposition equipment with a quick release function according to claim **1**, wherein the air intake line extends from the shaft sealing device into the reaction space of the vacuum chamber and forms an extension tube in the reaction space.

13. The powder atomic layer deposition equipment with a quick release function according to claim **12**, wherein the extension tube is configured with at least one vent hole on a terminal part or a wall thereof, for delivering a non-reactive gas to the reaction space.

14. The powder atomic layer deposition equipment with a quick release function according to claim **1**, wherein the vacuum chamber includes a cover plate and a chamber, and an inner surface of the cover plate is used to cover the chamber and forms the reaction space between the inner surface of the cover plate and the chamber, the inner surface of the cover plate being configured with a monitoring wafer, located in the reaction space.

15. A powder atomic layer deposition equipment with a quick release function, comprising:

a driving unit;

a shaft sealing device comprising an outer tube and an inner tube, the outer tube including an accommodating space for accommodating the inner tube, and the inner tube including at least one connecting space, wherein part of the inner tube protrudes from the outer tube;

a vacuum chamber comprising a recessed part located at a bottom of the vacuum chamber, the recessed part being used for accommodating said part of the inner tube protruding from the outer tube, with an enclosed space formed between the inner tube of the shaft sealing device and the recessed part of the vacuum chamber, wherein the vacuum chamber includes a reaction space for accommodating a plurality of powders, and the driving unit is connected to and rotates the vacuum chamber via the outer tube of the shaft sealing device;

at least one first seal ring and at least one second seal ring, located between the shaft sealing device and the vacuum chamber, wherein the enclosed space is located between the first seal ring and the second seal ring;

at least one first air extraction line, located in the shaft sealing device and fluidly connected to the enclosed space, wherein the first air extraction line is used in pumping gas out from the enclosed space to fix the vacuum chamber to the shaft sealing device; and

at least one air intake line, located in the shaft sealing device and fluidly connected to the reaction space of the vacuum chamber, for delivering a precursor gas into the reaction space.

16. The powder atomic layer deposition equipment with a quick release function according to claim **15**, wherein the first seal ring is disposed in the recessed part of the vacuum chamber.

17. The powder atomic layer deposition equipment with a quick release function according to claim **16**, wherein the second seal ring is configured at a side of the shaft sealing device to which the bottom of the vacuum chamber is connected, or sleeved on said part of the inner tube protruding from the outer tube.

18. The powder atomic layer deposition equipment with a quick release function according to claim **15**, wherein the recessed part extends from the bottom of the vacuum chamber to the reaction space and forms a protruding tubular part.

19. The powder atomic layer deposition equipment with a quick release function according to claim **18**, further comprising a filter unit located in the recessed part of the vacuum chamber, wherein the air intake line is fluidly connected to the reaction space of the vacuum chamber via the filter unit.

20. The powder atomic layer deposition equipment with a quick release function according to claim **15**, wherein the air intake line extends from the connecting space of the inner tube into the reaction space of the vacuum chamber and forms an extension tube in the reaction space.

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