

VIA DEPOSITION PROCESS ON SUBSTRATE AND SEMICONDUCTOR PROCESSING APPARATUS

FIELD OF THE INVENTION

The present invention belongs to the technology field of semiconductor processing, and specifically relates to a via deposition process on a substrate and a semiconductor processing apparatus.

BACKGROUND OF THE INVENTION

A dual inlaying process (also referred to as a dual-Damascene process) has been widely used among techniques of copper interconnecting. Specially, as shown in Fig. 1, the dual inlaying process includes the following steps:

step S1: depositing, on an upper surface of a substrate, a silicon nitride thin film 1 that is used for stopping an etching on a dielectric material layer 2 formed by subsequent deposition;

step S2: depositing, on a surface of the silicon nitride thin film 1, the dielectric material layer 2 having a thickness and a low dielectric constant;

step S3: performing photolithography process on the dielectric material layer 2 so as to form a through hole pattern, which is used for implementing an interconnection line in a vertical direction, on the dielectric material layer 2;

step S4: etching the dielectric material layer 2 according to the through hole pattern to acquire a through hole 3 having a predetermined depth;

step S5: performing photolithography process on the dielectric material layer 2 so as to form a trench pattern, which is used for implementing an interconnection line in a horizontal direction, on the dielectric material layer 2;

step S6: etching the dielectric material layer 2 according to the trench pattern to acquire a trench 4 having a depth required by the process, and continuing to etch the through hole 3 according to the through hole pattern so as to allow the through hole 3 to reach a depth required by the process;

step S7: sequentially depositing, on the upper surface of the substrate, a barrier

layer 5 and a copper seed layer 6 by way of sputtering deposition, such that the barrier layer 5 and the copper seed layer 6 are sequentially deposited both on the upper surface of the substrate and within the through hole 3 and the trench 4 that are located on the upper surface of the substrate, wherein the barrier layer 5 is used for stopping copper atoms from diffusing to the dielectric material layer 2 and for enhancing the adhesion between the dielectric material layer 2 and the copper seed layer 6, and the copper seed layer 6 is used as a conductive layer in subsequent plating process;

step S8: depositing a copper layer on the upper surface of the substrate by using the plating process, such that the copper layer is formed on the upper surface of the substrate and the through hole 3 and the trench 4 which are located on the upper surface; and

step S9: performing a planarization process, by way of an annealing process and a chemical-mechanical polishing process, and a cleaning process on the copper layer positioned on the upper surface of the substrate.

Here, the depositing of the copper seed layer in step S7 is one of the key steps in the copper interconnecting process, which specifically includes the following steps as shown in Fig. 2:

step S71: performing a degas process, in which volatile gas impurities on a surface of the substrate is removed by means of heating to guarantee the electric performance of the subsequent copper layer;

step S72: performing a pre-cleaning process, in which nonvolatile gas impurities on the surface of the substrate is removed by a method of plasma etching to guarantee the electric performance of the subsequent copper layer;

step S73: depositing the barrier layer 5 (for example, tantalum nitride or tantalum) on the upper surface of the substrate by way of magnetron sputtering, such that the barrier layer 5 is deposited both on the upper surface of the substrate and within the through hole 3 and the trench 4 that are located on the upper surface of the substrate; and

step S74: depositing the copper seed layer 6 on the upper surface of the substrate, such that the copper seed layer 6 is deposited both on the upper surface of the

substrate and within the through hole 3 and the trench 4 that are located on the upper surface of the substrate.

In step S74, the magnetron sputtering process is performed by using a semiconductor processing apparatus described below to deposit the copper seed layer 6 both on the upper surface of the substrate and within the through hole 3 and the trench 4 that are located on the upper surface of the substrate. Specifically, as shown in Fig. 3, the semiconductor processing apparatus includes a reaction chamber 10, a copper target material 11 is provided at a top inside the reaction chamber 10, and a magnetron 12 having a high ionization rate is provided on top of the copper target material 11, which is used to attain highly ionized ions of the target material; a carrying device 13 configured for carrying a substrate is provided in the reaction chamber 10 and under the copper target material 11, and is electrically connected to a radio frequency (RF) power supply 14. The RF power supply 14 is configured for supplying RF power to the carrying device 13 so as to improve directionality of the target material particles, so the coverage ratio of the copper seed layer 6 on a top overhanging region and an inner side wall of a via (the through hole 3 and the trench 4) can be well controlled to meet requirements of the subsequent plating process, and the complete filling of the via is allowed to meet process requirement.

However, the above magnetron sputtering process only can ensure certain coverage ratio on an inner side wall of a large-dimension via corresponding to a technology node above 22nm, while cannot manage the coverage ratio on an inner side wall of a small-dimension via corresponding to a technology node below 22nm, thereby the result of the subsequent and complete filling of the via cannot meet process requirement. Therefore, how to increase the coverage ratio on an inner side wall of a small-dimension via is a technical problem that is urgent to be solved for those skilled in the art.

SUMMARY OF THE INVENTION

The present invention is intended to solve technical problems existing in the prior art, and provides a via deposition process on a substrate and a semiconductor

processing apparatus, which can increase the coverage ratio on an inner side wall of a small-dimension via, and thus provides excellent conditions for improving process quality of subsequent filling process of the small-dimension via.

To solve the above technical problems, the present invention provides a via deposition process on a substrate, wherein a metal particle migration procedure is performed at least once, and the metal particle migration procedure includes the following steps: step S100, forming, by way of sputtering deposition, a metal layer within a via on a substrate; and step S200, heating the substrate on which the metal layer is formed to a predetermined temperature, so as to allow metal particles of the metal layer to migrate gradually from an upper portion of the via to a bottom portion of the via.

Optionally, in the step S200, the predetermined temperature is in a range from 200°C to 300°C.

Optionally, process temperature adopted during the step S100 is in a range less than 60°C.

Optionally, the performing of the metal particle migration procedure at least once includes: repeatedly performing the metal particle migration procedure until the interior of the via is completely filled with the metal particles.

Optionally, after the performing of the metal particle migration procedure at least once, the process further includes a plating-process filling procedure, that is, depositing metal on an upper surface of the substrate by using a plating process until the interior of the via on the substrate is completely filled with the metal particles.

As another technical aspect, the present invention further provides a semiconductor processing apparatus, which includes a reaction chamber, a heating chamber and a delivery device, wherein the reaction chamber is configured for forming a metal layer within a via on a substrate by way of sputtering deposition, the heating chamber is configured for heating the substrate on which the metal layer is formed to a predetermined temperature so as to allow metal particles of the metal layer to migrate gradually from an upper portion of the via to a bottom portion of the via, and the delivery device is configured for delivering the substrate between the

reaction chamber and the heating chamber.

Optionally, the heating chamber is provided outside a side wall of the reaction chamber, and is connected with the reaction chamber.

Optionally, the delivery device includes a carrying arm and a rotation driving mechanism, wherein the carrying arm is configured for carrying the substrate, and the rotation driving mechanism is configured for driving the carrying arm to rotate around a rotation axis of the carrying arm so as to deliver the substrate between the reaction chamber and the heating chamber.

Optionally, a heating device is provided inside the heating chamber, which is configured for heating the substrate to the predetermined temperature when the substrate is in the heating chamber.

Optionally, the predetermined temperature is in a range of 200°C to 300°C.

Optionally, the heating device includes an infrared heating bulb, an electric heating resistance wire or an induction coil.

Beneficial effects of the present invention are as follows.

In the via deposition process on a substrate provided by the present invention, the metal particle migration procedure is performed at least once, and the metal particle migration procedure includes the following steps S100 and S200, wherein in step S100, the metal layer is formed within the via on the substrate by way of sputtering deposition, and in step S200, the substrate on which the metal layer is formed is heated to the predetermined temperature, such that the migration capability of the metal particles at the predetermined temperature is enhanced to implement the gradual migration of the metal particles from the upper portion of the via to the bottom portion of the via. In such the migration process, the metal particles at an overhanging region of the top portion of the via may migrate downward to the inner side wall and the bottom portion of the via, and thus the coverage ratio of the metal particles on the inner side wall of the via is increased, which provides excellent conditions for subsequent filling process. Since the coverage ratio of the metal particles on the inner side wall of the via is increased by means of the metal particle migration procedure in the via deposition process on a substrate provided by the present invention, the

process has no special requirement for the dimension of the via, and is applicable for both a large-dimension via corresponding to a technology node above 22nm and a small-dimension via corresponding to a technology node below 22nm, thereby having a wide range of application.

In an embodiment of the present invention, the metal particle migration procedure is repeatedly performed until the interior of the via is completely filled with the metal particles. As such, not only the coverage ratio of the metal particles on the inner side wall of the via can be further increased, but also the complete filling of the via can be directly implemented, thereby improving efficiency and quality of the process.

In another embodiment of the present invention, after the metal particle migration procedure is performed at least once, a plating-process filling procedure further needs to be performed, that is, depositing metal on the upper surface of the substrate by using a plating process until the interior of the via on the substrate is completely filled with the metal particles. As such, by the performing of the metal particle migration procedure at least once, the coverage ratio of the metal particles on the inner side wall of the via can be increased, thereby providing excellent conditions for the subsequent plating-process filling procedure and avoiding defects formed in the plating process; in addition, by means of the plating-process filling procedure, the via can be completely filled, thereby improving process quality.

The semiconductor processing apparatus provided by the present invention includes a reaction chamber, a heating chamber and a delivery device, wherein the delivery device is capable of delivering the substrate between the reaction chamber and the heating chamber, and the heating chamber is capable of heating the substrate that is formed with the metal layer in the reaction chamber to the predetermined temperature, such that the migration capability of the metal particles at the predetermined temperature is enhanced to implement the gradual migration of the metal particles from the upper portion of the via to the bottom portion of the via; and during the migration procedure, the metal particles at an overhanging region of the top portion of the via may migrate downward to the inner side wall and the bottom

portion of the via, and thus the coverage ratio of the metal particles on the inner side wall of the via is increased, which provides excellent conditions for subsequent filling process of the via, and the process quality is increased. Further, for the semiconductor processing apparatus provided by the present invention, since the coverage ratio of the metal particles on the inner side wall of the via is increased by means of the metal particle migration procedure, there is no special requirement for the dimension of the via, and the range of application is wide.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic flow chart of a conventional dual inlaying process;

Fig. 2 is a schematic flow chart of step S7 in Fig. 1;

Fig. 3 is a structural schematic diagram of a reaction chamber of a conventional magnetron sputtering apparatus;

Fig. 4 is a schematic shape diagram of a via in step S100 of a via deposition process on a substrate provided by an embodiment of the present invention;

Fig. 5 is a diagram illustrating a shape changing procedure of the via shown in Fig. 4 during step S200 of an embodiment of the present invention;

Fig. 6 is a structural schematic diagram of a semiconductor processing apparatus provided by an embodiment of the present invention; and

Fig. 7 is a diagram illustrating a trace of delivering the substrate between a reaction chamber and the heating chamber.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The essence of the present invention is to provide a via deposition process on a substrate and a corresponding semiconductor processing apparatus, in which the migration capability of metal particles at a predetermined temperature is increased by heating a substrate on which a metal layer is formed to the predetermined temperature, so the metal particles migrate gradually from an upper portion of a via to a bottom portion of the via, and in the migration process, the metal particles at an overhanging region of the top portion of the via may migrate downward to the inner side wall and

the bottom portion of the via, and thus the coverage ratio of the metal particles on the inner side wall of the via is increased, which provides excellent conditions for subsequent filling process. Further, since the coverage ratio on the inner side wall of the via with the metal particles is increased by means of the metal particle migration procedure in the present invention, there is no special requirement for the dimension of the via, and the range of application is wide.

To make those skilled in the art better understand the technical solutions of the present invention, a via deposition process on a substrate and a semiconductor processing apparatus provided by the present invention will be described in detail below in conjunction with the accompanying drawings.

Fig. 4 is a schematic shape diagram of a via in step S100 of a via deposition process on a substrate provided by an embodiment of the present invention. Fig. 5 is a diagram illustrating a shape changing procedure of the via shown in Fig. 4 during step S200 of an embodiment of the present invention. With reference to Figs. 4 and 5, in the via deposition process on a substrate provided by the embodiment, a metal particle migration procedure is performed at least once, and the metal particle migration procedure includes the following steps:

step S100, forming, by way of sputtering deposition, a metal layer within a via on a substrate, wherein the metal includes copper, aluminum or the like; and

step S200, heating the substrate on which the metal layer is formed to a predetermined temperature, so as to allow metal particles of the metal layer to migrate gradually from an upper portion of the via to a bottom portion 3 of the via. Here, the upper portion of the via includes an overhanging region 2 of a top portion of the via and an inner side wall 1 above the bottom portion 3 of the via.

The depositing of copper metal within the via by using the via deposition process on a substrate provided by the embodiment will be described in detail below in conjunction with Figs. 4 and 5.

First, a metal particle migration process including steps S100 and S200 is performed.

Specifically, in step S100, copper particles having a direction of motion towards

the inner side wall 1 of the via do not readily enter into the via due to a small dimension of the via, and thus the copper layer deposited on the inner side wall 1 of the via is made thin, while the metal layer deposited at the overhanging region 2 of the top portion of the via and the bottom portion 3 of the via is relatively thick, as shown in Fig. 4. In addition, it causes the fact that the coverage ratio on the overhanging region 2 of the top portion of the via and the inner side wall 1 of the via cannot be well controlled, that is, excessive amount of the metal layer is deposited on a portion of the overhanging region 2 of the top portion of the via, on which no metal layer or a small amount of the metal layer is expected to be deposited, while no metal layer is deposited on a portion of the inner side wall 1 of the via, on which the metal layer is expected to be deposited.

Next, in step S200, the substrate having a via of a shape as shown in Fig. 4 is heated to a predetermined temperature, in particular, the predetermined temperature may be in a range from 200°C to 300°C. This allows the fact that migration capacity of copper particles of the copper layer is increased under the condition that the chamber is in vacuum state and has the predetermined temperature, and the copper particles migrate gradually from the upper portion of the via to the bottom portion 3 of the via under the effect of the atomic mass thereof. Fig. 5 illustrates a shape changing procedure of the via shown in Fig. 4 during step S200 of the via deposition process on a substrate provided by the embodiment of the present invention. Here, in period I, the copper layer deposited on the inner side wall 1 of the via is thin, and the metal layer deposited at the overhanging region 2 of the top portion of the via and the bottom portion 3 of the via is relatively thick; in period II, the copper particles migrate gradually from the upper portion of the via to the bottom portion 3 of the via, during which the metal particles at the overhanging region 2 of the top portion of the via may migrate downward to the inner side wall 1 of the via and the bottom portion 3 of the via, and some metal particles on the inner side wall 1 of the via may also migrate to the bottom portion 3 of the via, so the copper layer deposited at the upper portion of the via become thin while the metal layer deposited at the bottom portion 3 of the via become thick gradually; and in period III, the copper particles continues to migrate

from the upper portion of the via to the bottom portion 3 of the via, the copper layer deposited at the upper portion of the via further become thin, and the metal layer deposited at the bottom portion 3 of the via further become thick. In practice application, the range of the predetermined temperature is specifically set depending on the metal material to be deposited in the process, as long as the migration capability of the metal particles can be enhanced at the predetermined temperature.

Then, the metal particle migration procedure is performed repeatedly, that is, the above steps S100 and S200 are performed repeatedly to keep on the repeated migration of the copper particles gradually from the upper portion of the via to the bottom portion 3 of the via, and thus the copper particles deposited at the bottom portion 3 of the via become thicker and thicker. The above steps S100 and S200 are performed repeatedly until the interior of the via is completely filled with the metal particles (copper particles), thereby implementing the complete filling of the interior of the via with the metal particles. As such, by repeatedly performing the metal particle migration procedure to completely fill the interior of the via with the metal particles, not only the coverage ratio of the metal particles on the inner side wall 1 of the via can be further increased, but also the complete filling of the via can be directly implemented, instead of implementing the complete filling of the via by adding a plating process, thereby improving efficiency and quality of the process.

In practice application, by means of the via deposition process on a substrate provided by the embodiment, the metal copper can be deposited within the via to implement a copper interconnection line. Further, in order to implement the copper interconnection line, the process further includes the following steps before step S100:

step S101, depositing, on an upper surface of a substrate, a silicon nitride thin film that is used for stopping an etching on a dielectric material layer formed by subsequent deposition;

step S102, depositing, on a surface of the silicon nitride thin film, the dielectric material layer having a thickness and a low dielectric constant; and

step S103: etching a via on the dielectric material layer, wherein the via includes a trench used for implementing an interconnection line in a horizontal direction and a

through hole used for implementing an interconnection line in a vertical direction.

In practice application, after performing the metal particle migration procedure at least once and completely filling the interior of the via with the metal particles, the process may further include step S310: performing a planarization process, by way of an annealing process and a chemical-mechanical polishing process, and a cleaning process on the copper layer positioned on the upper surface of the substrate

It needs to be noted that, although the complete filling of the via with the metal particles is implemented by repeatedly performing the metal particle migration procedure in the above embodiment, the present invention is not limited thereto. In practice application, after the performing of the metal particle migration procedure at least once, the process may further include a plate-process filling procedure, that is, depositing the copper metal on the upper surface of the substrate by using the plating process until the interior of the via is completely filled with the metal particles (copper particles). As such, by the performing of the metal particle migration procedure at least once, the coverage ratio of the metal particles on the inner side wall of the via can be increased, thereby providing excellent conditions for the subsequent plating-process filling procedure and avoiding defects formed in the plating process; in addition, by means of the plating-process filling procedure, the via can be completely filled, thereby improving process quality. It can be understood that, in order to meet the requirements of the plating process, the metal particle migration procedure can be repeated predetermined times to ensure that the coverage ratio on the overhanging region 1 of the top portion of the via and the inner side wall 1 of the via meets the requirements of the plating.

It further needs to be noted that, a copper target material is provided at the top inside the chamber in which step S100 is completed, and a magnetron having a high ionization rate is provided on the copper target material, which is used to attain highly ionized ions of the target material; and, the copper target material is electrically connected to a direct current (DC) power supply, so as to excite the process gas in the chamber to form plasma and apply a negative bias voltage to the copper target material to attract the plasma to bombard the copper target material, which allows

copper particles, escaping from a surface of the copper target material by bombarding, to be deposited on a surface of the substrate to form a copper layer, wherein the DC power supply has an output power around 3kW; a carrying device configured for carrying a substrate is provided in the chamber and under the copper target material, the carrying device is connected to a RF power supply, and the RF power supply is configured for supplying RF power to the carrying device to improve directionality of the target material particles and has an output power around 400W. In addition, the chamber has a gas pressure around 0 mTorr, and the process temperature adopted in step S100 is in a range less than 60°C.

It further needs to be noted that, in the embodiment, the specific operating process of depositing the metal copper within the via by using the via deposition process on a substrate provided by the embodiment is described in detail, but the present invention is not limited thereto. In practice application, other metal may be deposited with the via by using the via deposition process on a substrate provided by the embodiment, and the operating process thereof is similar to that of the above depositing of the metal copper, except that specific parameters in the deposition process need to be set depending to various metal materials, for example, relevant parameters such as the mode of magnetron sputtering in step S100, the predetermined temperature in step S200 and the like.

From the above, according to the via deposition process on a substrate provided by the embodiment of the present invention, in step S100, the metal layer is formed within the via, and in step S200, the substrate on which the metal layer is formed is heated to the predetermined temperature, such that the migration capability of the metal particles at the predetermined temperature is enhanced to implement the gradual migration of the metal particles from the upper portion of the via to the bottom portion of the via, and thus the coverage ratio of the metal particles on the inner side wall of the via is increased, which provides excellent conditions for subsequent filling process. Since the coverage ratio of the metal particles on the inner side wall of the via is increased by means of the metal particle migration procedure in the via deposition process on a substrate provided by the embodiment of the present invention, the

process has no special requirement for the dimension of the via and has a wide range of application, for example, the process is applicable for both a large-dimension via corresponding to a technology node above 22nm and a small-dimension via corresponding to a technology node below 22nm.

As another technical solution, the present invention further provides a semiconductor processing apparatus. Fig. 6 is a structural schematic diagram of a semiconductor processing apparatus provided by an embodiment of the present invention. Fig. 7 is a diagram illustrating a trace of delivering the substrate between a reaction chamber and the heating chamber. With reference to Figs. 6 and 7, the semiconductor processing apparatus provided by the embodiment includes a reaction chamber 20, a heating chamber 21 and a delivery device 22. Here, the reaction chamber 20 is configured for forming a metal layer within a via on a substrate by way of sputtering deposition, and the metal includes copper, aluminum or the like; the delivery device 22 is configured for delivering the substrate between the reaction chamber 20 and the heating chamber 21; and the heating chamber 21 is configured for heating the substrate to a predetermined temperature so as to allow metal particles of the metal layer to migrate gradually from an upper portion of the via to a bottom portion of the via. By means of the migration of the metal particles, the metal particles at the overhanging region of the top portion of the via may migrate downward to the inner side wall and the bottom portion of the via, and thus the coverage ratio of the metal particles on the inner side wall of the via is increased, which provides excellent conditions for subsequent filling process. Further, for the semiconductor processing apparatus provided by the embodiment of the present invention, since the coverage ratio of the metal particles on the inner side wall of the via is increased by means of the metal particle migration procedure, there is no special requirement for the dimension of the via, and the range of application is wide. For example, the semiconductor processing apparatus is applicable for both a large-dimension via corresponding to a technology node above 22nm and a small-dimension via corresponding to a technology node below 22nm.

Specifically, in the embodiment, as shown in Fig. 6, a metal target material 201 is

provided at the top inside the reaction chamber 20, and a magnetron 202 having a high ionization rate is provided on the metal target material 201, which is used to attain highly ionized ions of the target material; and, the metal target material 201 is electrically connected to a direct current (DC) power supply, so as to excite the process gas in the reaction chamber 20 to form plasma and apply a negative bias voltage to the metal target material 201 to attract the plasma to bombard the metal target material, which allows metal particles, escaping from a surface of the metal target material 201 by bombarding, to be deposited on a surface of the substrate to form a metal layer; a carrying device 203 configured for carrying a substrate is provided in the reaction chamber 20 and under the metal target material 201, the carrying device 203 is connected to a RF power supply 204, and the RF power supply 204 is configured for supplying RF power to the carrying device 203 to improve directionality of the target material particles. To form the copper layer within the via on the substrate in the reaction chamber 20, the metal target material is a copper target material, the RF power supply 204 has an output power around 400W, the reaction chamber 20 has a gas pressure around 0 mTorr and a temperature less than 60°C, and the DC power supply has an output power around 3kW.

In addition, the heating chamber 21 is provided outside a side wall of the reaction chamber 20, and is connected with the reaction chamber 20; and a heating device 211 is provide inside the heating chamber 21, which is configured for heating the substrate to the predetermined temperature when the substrate is in the heating chamber 21. When the metal is copper, the predetermined temperature is in a range from 200°C to 300 °C . Preferably, the heating device 211 includes an infrared heating bulb performing heating by means of infrared, and the infrared heating bulb is provided on the top wall of the heating chamber 21. In practice application, the heating device 211 may employ other heating means such as an electric heating resistance wire, an induction coil or the like.

The delivery device 22 includes a carrying arm 221 and a rotation driving mechanism 222, wherein the carrying arm 221 is configured for carrying the substrate, and the rotation driving mechanism 222 is configured for driving the carrying arm 221

to rotate around a rotation axis 2221 of the carrying arm 221 so as to drive the substrate to be delivered between the reaction chamber 20 and the heating chamber 21. Specifically, to implement the delivery of the substrate between the reaction chamber 20 and the heating chamber 21 by the delivery device 22, an ejector pin lifting mechanism 205 is further provided inside the reaction chamber 20, which is provided under the carrying device 203 and can penetrate through the carrying device 203 to perform lifting, so as to eject or put down the substrate positioned on the upper surface of the carrying device 203.

In conjunction with Fig. 7, it will be described in detail below how the ejector pin lifting mechanism 205 and the delivery device 22 jointly implement the delivery of the substrate. Specifically, a process position A is defined as a position at which a substrate is carried on an upper surface of the carrying base 203, and a process position B is defined as a predetermined position at which the substrate is heated inside the heating chamber 21. An operating process of delivering a substrate from the process position A of the reaction chamber 20 to the process position B of the heating chamber 21 is that: the ejector pin lifting mechanism 205 raises to eject the substrate, and allows the substrate to be higher than the process position B in a vertical direction; the rotation driving mechanism 222 drives the carrying arm 221 to rotate around the rotation axis 2221 and to be turned into the reaction chamber 20 and right under the substrate; the ejector pin lifting mechanism 205 falls to put down the substrate onto the carrying arm 221; and the rotation driving mechanism 222 drives the carrying arm 221 to reversely rotate around the rotation axis 2221 to the process position B of the heating chamber 21. The process of delivery from the process position B of the heating chamber 21 to the process position A of the reaction chamber 20 is similar to the above process except that the operation sequence is converse, and thus the description thereof is omitted herein.

Therefore, by means of the joint use of the ejector pin lifting mechanism 205 and the delivery device 22, the substrate can be moved along the movement trace S as shown in Fig. 7, either from the position A of the reaction chamber 20 to the position B of the heating chamber 21, or from the position B of the heating chamber 21 to the

position A of the reaction chamber 20. In practice application, other delivery devices 22 can be employed to implement the delivery of the substrate between the reaction chamber 20 and the heating chamber, which are not limited exhaustively.

Further, when the delivery device 22 delivers the substrate between the reaction chamber 20 and the heating chamber back and forth, the deposition process inside the reaction chamber 20 and the heating process inside the heating chamber can be repeatedly performed, and thus the migration of metal particles can be repeatedly performed until the interior of the via is completely filled with the metal particles. As such, not only the coverage ratio of the metal particles on the inner side wall of the via can be further increased, but also the complete filling of the via can be directly implemented, thereby improving efficiency and quality of the process.

It needs to be noted that, the semiconductor processing apparatus provided by the embodiment is employed to implement a via deposition process on a substrate, the operating process of which is similar to that of the via deposition process on a substrate provided by the above embodiment and is not described herein.

It further needs to be noted that, in the embodiment, the heating chamber 21 is connected with the reaction chamber 20. However, in practice application, in order to prevent the environments of the two chambers from affecting each other, a valve can be provided between the two chambers, and the connection or disconnection between the heating chamber 21 and the reaction chamber 20 is implemented by controlling the valve to be turned on or turned off.

It further needs to be noted that, in practice application, specific parameters (for example, parameters such as temperature, gas pressure, output power of the DC power supply, output power of the RF power supply and the like inside the reaction chamber 20, and parameters such as heating power of the heating device 211, the predetermined temperature to which the substrate needs to be heated and the like inside the heating chamber 21) of the semiconductor processing apparatus can be set depending on various metal materials.

It can be understood that the foregoing implementations are merely exemplary

implementations used for describing the principle of the present invention, but the present invention is not limited thereto. Those of ordinary skill in the art may make various variations and improvements without departing from the spirit and essence of the present invention, and these variations and improvements shall fall into the protection scope of the present invention.

What is claimed is:

1. A via deposition process on a substrate, characterized in that, a metal particle migration procedure is performed at least once, and the metal particle migration procedure includes the following steps:

step S100, forming, by way of sputtering deposition, a metal layer within a via on a substrate; and

step S200, heating the substrate on which the metal layer is formed to a predetermined temperature, so as to cause metal particles of the metal layer to migrate gradually from an upper portion of the via to a bottom portion of the via.

2. The via deposition process on a substrate according to claim 1, characterized in that, in the step S200, the predetermined temperature is in a range from 200°C to 300°C.

3. The via deposition process on a substrate according to claim 1, characterized in that, process temperature adopted for the step S100 is in a range less than 60°C.

4. The via deposition process on a substrate according to any one of claims 1 to 3, characterized in that, the performing of the metal particle migration procedure at least once includes: repeatedly performing the metal particle migration procedure until the interior of the via is completely filled with the metal particles.

5. The via deposition process on a substrate according to any one of claims 1 to 3, characterized in that, after the performing of the metal particle migration procedure at least once, further includes a plating-process filling procedure, in which metal is deposited on an upper surface of the substrate by using a plating process until the interior of the via on the substrate is completely filled with the metal particles.

6. A semiconductor processing apparatus, comprising a reaction chamber, a

heating chamber and a delivery device, wherein

the reaction chamber is configured for forming a metal layer within a via on a substrate by way of sputtering deposition;

the heating chamber is configured for heating the substrate on which the metal layer is formed to a predetermined temperature so as to allow metal particles of the metal layer to migrate gradually from an upper portion of the via to a bottom portion of the via; and

the delivery device is configured for delivering the substrate between the reaction chamber and the heating chamber.

7. The semiconductor processing apparatus according to claim 6, characterized in that, the heating chamber is provided outside a side wall of the reaction chamber, and is connected with the reaction chamber.

8. The semiconductor processing apparatus according to claim 6, characterized in that, the delivery device includes a carrying arm and a rotation driving mechanism, wherein

the carrying arm is configured for carrying the substrate; and

the rotation driving mechanism is configured for driving the carrying arm to rotate around a rotation axis of the carrying arm so as to deliver the substrate between the reaction chamber and the heating chamber.

9. The semiconductor processing apparatus according to claim 6, characterized in that, a heating device is provided inside the heating chamber, which is configured for heating the substrate to the predetermined temperature when the substrate is in the heating chamber.

10. The semiconductor processing apparatus according to claim 6, characterized in that, the predetermined temperature is in a range from 200°C to 300°C.

11. The semiconductor processing apparatus according to claim 9, characterized in that, the heating device includes an infrared heating bulb, an electric heating resistance wire or an induction coil.