

SEMICONDUCTOR PROCESS CHAMBER AND UPPER ELECTRODE STRUCTURE THEREOF

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TECHNICAL FIELD

[0001] The present disclosure relates to the field of semiconductor process equipment, and in particular, to an upper electrode structure and a semiconductor process chamber including the same.

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BACKGROUND

[0002] The Physical Vapor Deposition (PVD) technology is a commonly used coating process in a manufacturing process of an Integrated Circuit (IC). As shown in FIG. 1 which is a schematic structural diagram of a typical PVD apparatus, in a process of performing a PVD process with the PVD apparatus, a wafer is first placed on a base 1, a power supply 9 applies a voltage to a target 5, an inert gas (e.g., argon (Ar)) is then introduced into a chamber 2 from a gas source 7, the inert gas is ionized at a high voltage, and the ionized atoms bombard the target 5 under the action of a magnetic field generated by a magnetron component 6, so that atoms on a surface of the target fall off and are deposited on a surface of the wafer on the base 1, thereby achieving coating by magnetron sputtering deposition. A liner 3 is configured to prevent the atoms of the target from being deposited on an inner wall of the chamber 2 during the sputtering, so as to ensure cleanliness of the chamber.

[0003] In the sputtering process, the magnetron component 6 on the back of the target 5 generates the magnetic field, so that electrons in plasma rotate around magnetic induction lines of the magnetic field; and the number of times of bombardments between the target 5 and the atoms from the inert gas is increased with an increase in motion tracks of the electrons, thereby increasing the amount of the plasma. A rotary drive component 8 is configured to drive the magnetron component 6 to rotate around a vertical rotation axis, so as to improve circumferential uniformity of an effect of driving, by the magnetic field, the ionized atoms to bombard the target 5. The positions at the

target 5 which are bombarded by the ionized atoms are concentrated at the positions where the magnetic induction lines of the magnetic field are parallel to the surface of the target 5, so that the strength of the magnetic field and the density of the plasma near a lower surface of the target are highly related to a distance between the magnetron component 6 and the target 5 in a vertical direction. In order to ensure uniformity and efficiency of atomic deposition, the IC manufacturing process proposes a high requirement on height control accuracy of the magnetron component 6.

[0004] Therefore, how to provide a semiconductor process chamber structure capable of accurately monitoring a height of a magnetron is an urgent technical problem to be solved in the art.

SUMMARY

[0005] The present disclosure aims to provide an upper electrode structure capable of accurately monitoring a height of a magnetron component, and a semiconductor process chamber including the upper electrode structure.

[0006] In order to achieve the above objective, in one aspect of the present disclosure, there is provided an upper electrode structure applied to a semiconductor process chamber, including a magnetron component, an emitting component, a receiving component, a target, and a signal processing device; wherein

the magnetron component is located above the target and is configured to provide a magnetic field for an interior of the semiconductor process chamber;

the emitting component and the receiving component are disposed opposite to each other on two sides of the magnetron component along a horizontal direction;

the emitting component is configured to transmit a plurality of optical signals to the receiving component, and the plurality of optical signals are a plurality of light beams that horizontally propagate and are arranged at intervals along a vertical direction;

the receiving component is configured to receive the plurality of optical signals, convert the plurality of optical signals into electrical signals, and send the electrical signals to the signal processing device; and

the signal processing device is configured to determine a vertical distance between the magnetron component and the target according to the electrical signals.

[0007] Optionally, the emitting component includes a plurality of light-emitting elements disposed at intervals along the vertical direction, the receiving component includes a plurality of light-sensitive elements disposed at intervals along the vertical direction, the plurality of light-emitting elements are configured to transmit the optical signals to the plurality of light-sensitive elements in a one-to-one correspondence manner, and the plurality of light-sensitive elements are configured to receive the optical signals transmitted by the corresponding light-emitting elements, convert the optical signals into the electrical signals, and send the electrical signals to the signal processing device.

[0008] Optionally, the signal processing device is configured to determine a distance between a first light-sensitive element and an active light-sensitive element in the vertical direction according to the electrical signals sent by the light-sensitive elements, and determine the vertical distance between the magnetron component and the target according to the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction and a prestored distance between the first light-sensitive element and the target in the vertical direction; wherein

the first light-sensitive element is a light-sensitive element at a highest position, and the active light-sensitive element is a light-sensitive element in the vertical direction that firstly receives an electrical signal and is lower than the light-sensitive elements not receiving the electrical signals.

[0009] Optionally, the vertical distance satisfies a following relational expression:

$$D=H-h;$$

where D is the vertical distance between the target and the magnetron component, H is the distance between the first light-sensitive element and the target in the vertical direction, and h is the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction.

[0010] Optionally, the plurality of light-emitting elements are disposed at equal intervals along the vertical direction, the plurality of light-sensitive elements are disposed at equal intervals along the vertical direction and are sequentially numbered along the vertical direction; and the signal processing device is configured to determine the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction according to a difference between a number of the active light-sensitive element and a number of the first light-sensitive element.

[0011] Optionally, the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction satisfies a following relational expression:

$$h=(i-1)\times t;$$

5 where h is the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction, i is the number of the active light-sensitive element, and t is a distance between every two adjacent light-sensitive elements in the vertical direction.

[0012] Optionally, the signal processing device is further configured to determine a
10 lifting height of the magnetron component according to a difference between a number of a corresponding active light-sensitive element after a height of the magnetron component is changed and a number of a corresponding active light-sensitive element before the height of the magnetron component is changed.

[0013] Optionally, the lifting height of the magnetron component satisfies a following
15 relational expression:

$$L=(m-n)\times t;$$

where L is the lifting height of the magnetron component, m is the number of the corresponding active light-sensitive element after the height of the magnetron component is changed, n is the number of the corresponding active light-sensitive
20 element before the height of the magnetron component is changed, and t is a distance between every two adjacent light-sensitive elements in the vertical direction.

[0014] Optionally, the upper electrode structure further includes an upper cover, a mounting cylinder, and a rotary drive component; wherein

the upper cover is fixedly disposed at a top end of the mounting cylinder, and the rotary
25 drive component passes through a through hole of the upper cover, and is connected to the magnetron component in the mounting cylinder for driving the magnetron component to rotate; and

a bottom end of the mounting cylinder is used for fixed arrangement of the target, two mounting through holes are formed on a cylinder wall of the mounting cylinder and
30 penetrate through the cylinder wall along a radial direction, the two mounting through holes are arranged opposite to each other on two sides of an axis of the mounting cylinder, and the emitting component and the receiving component are respectively disposed in the two mounting through holes.

[0015] In a second aspect of the present disclosure, there is provided a semiconductor process chamber, including the upper electrode structure described above.

[0016] Optionally, the semiconductor process chamber further includes a control device, which is configured to give an alarm when the vertical distance exceeds a preset distance range.

[0017] In the upper electrode structure and the semiconductor process chamber provided in the present disclosure, the upper electrode structure includes the emitting component and the receiving component which are disposed on two sides of the magnetron component, the emitting component is configured to transmit the plurality of optical signals to the receiving component, the plurality of optical signals are a plurality of light beams that horizontally propagate and are arranged at intervals along the vertical direction, and the magnetron component is located between the emitting component and the receiving component, so that the magnetron component can block the light beams emitted by the emitting component within a corresponding height range, and the receiving component cannot receive the light beams within the height range. Thus, the signal processing device can determine the vertical distance between the magnetron component and the target in real time according to a situation of reception of the light beams by the receiving component, which improves efficiency of determining a height of the magnetron component. Moreover, after the height of the magnetron component is changed in a semiconductor process (for example, the height of the magnetron component needs to be adjusted in some processes, or the magnetron component is displaced due to poor fixation), the signal processing device can also monitor a position of the magnetron component on time after the magnetron component is raised or lowered, which ensures accuracy of the position of the magnetron component, thereby improving a semiconductor process effect.

BRIEF DESCRIPTION OF DRAWINGS

[0018] The accompany drawings are intended to provide a further understanding of the present disclosure and constitute a part of the specification. Together with the following specific implementations, the drawings are used to explain the present disclosure, but do not constitute any limitation to the present disclosure. In the drawings:

[0019] FIG. 1 is a schematic structural diagram of an existing PVD apparatus;

be confirmed only in a disassembling state of the machine, and a current position of the magnetron component 6 cannot be confirmed after a height of the magnetron component 6 is changed during an operating process of the machine, such that a semiconductor process effect cannot be ensured.

[0028] In order to solve the above technical problem, in an aspect of the present disclosure, there is provided an upper electrode structure applied to a semiconductor process chamber. As shown in FIG. 2, the upper electrode structure includes a magnetron component 20, an emitting component 30, a receiving component 40, a target 70, and a signal processing device 50, and the magnetron component 20 is located above the target 70 and is configured to provide a magnetic field for an interior of the semiconductor process chamber; and the emitting component 30 and the receiving component 40 are disposed opposite to each other on two sides of the magnetron component 20 along a horizontal direction, and optionally, the emitting component 30 and the receiving component 40 are symmetrically disposed with respect to an axial center line of the magnetron component 20. Moreover, height ranges of the emitting component 30 and the receiving component 40 correspond to a height range of the magnetron component 20, so as to enable the magnetron component to block light emitted from the emitting component within the corresponding height range. The emitting component 30 is configured to transmit a plurality of optical signals to the receiving component 40, and the plurality of optical signals are a plurality of light beams that horizontally propagate and are arranged at intervals along a vertical direction. The receiving component 40 is configured to receive the plurality of optical signals, convert the plurality of optical signals into electrical signals, and send the electrical signals to the signal processing device 50. The signal processing device 50 is configured to determine a vertical distance D between the magnetron component 20 and the target 70 according to the electrical signals.

[0029] In an alternative implementation of the present disclosure, as shown in FIG. 2, the upper electrode structure further includes a rotary drive component 10 configured to drive the magnetron component 20 to rotate around a vertical rotation axis. The upper electrode structure provided in the present disclosure is used for being disposed at a top of the semiconductor process chamber, that is, the rotation axis of the magnetron component 20 is vertically arranged in an operating state. Optionally, a projection position of the rotation axis on a horizontal plane is located at a center position of the

semiconductor process chamber, the rotary drive component 10 drives the magnetron component 20 to rotate around the rotation axis, so that the magnetron component 20 may provide a circumferentially uniform magnetic field for the interior of the semiconductor process chamber, thereby driving plasma in the semiconductor process chamber to bombard the target 70 below the magnetron component 20 (all high-low position relationships below refer to the positional relationships relative to the target 70 in the operating state of the upper electrode structure (i.e., the states shown in FIG. 2 and FIG. 7)).

[0030] In the present disclosure, the upper electrode structure includes the emitting component 30 and the receiving component 40 which are disposed on two sides of the magnetron component 20, the emitting component 30 is configured to transmit the plurality of optical signals to the receiving component 40, the plurality of optical signals are a plurality of light beams that horizontally propagate and are arranged at intervals along the vertical direction, and the magnetron component 20 is located between the emitting component 30 and the receiving component 40, so that the magnetron component 20 can block the light beams emitted by the emitting component 30 within a corresponding height range, and the receiving component 40 cannot receive the light beams within the height range. Thus, the signal processing device 50 can determine the vertical distance D between the magnetron component 20 and the target 70 in real time according to a situation of reception of the light beams by the receiving component 40, which improves efficiency of determining a height of the magnetron component 20. Moreover, after the height of the magnetron component 20 is changed in a semiconductor process (for example, the height of the magnetron component 20 needs to be adjusted in some processes, or the magnetron component 20 is displaced due to poor fixation), the signal processing device 50 can also monitor a position of the magnetron component 20 on time after the magnetron component 20 is raised or lowered, which ensures accuracy of the position of the magnetron component 20, thereby improving the semiconductor process effect.

[0031] In an alternative implementation of the present disclosure, the upper electrode structure further includes a case (or a base) configured to maintain relative positions of the rotary drive component 10, the magnetron component 20, the emitting component 30, the receiving component 40, and the target. Specifically, as shown in FIG. 2, the upper electrode structure further includes an upper electrode case 60, the magnetron

component 20 is disposed inside the upper electrode case 60, the rotary drive component 10 is fixedly disposed at a top of the upper electrode case 60, a bottom of the upper electrode case 60 is used for arrangement of the target 70, and the emitting component 30 and the receiving component 40 are both disposed on a side wall of the upper electrode case 60.

[0032] In an alternative implementation of the present disclosure, as shown in FIG. 3, the emitting component 30 includes a plurality of light-emitting elements 31 disposed at intervals along the vertical direction, the receiving component 40 includes a plurality of light-sensitive elements 41 disposed at intervals along the vertical direction, and the plurality of light-emitting elements 31 are configured to transmit the optical signals to the plurality of light-sensitive elements 41 in a one-to-one correspondence manner. The plurality of light-sensitive elements 41 of the signal processing device 50 are configured to receive the optical signals transmitted by the corresponding light-emitting elements 31, convert the optical signals into the electrical signals, and send the electrical signals to the signal processing device 50, so that the signal processing device 50 may determine which light-sensitive elements 41 receive the optical signals transmitted by the corresponding light-emitting elements 31 and which light-sensitive elements 41 do not receive the optical signals because the optical signals are blocked by the magnetron component 20, thereby determining the vertical distance between the magnetron component 20 and the target 70.

[0033] In an alternative implementation of the present disclosure, the light-emitting elements 31 are grating emitters, the light-sensitive elements 41 are photosensitive sensors, the grating emitters (the light-emitting elements 31) may transmit the optical signals (e.g., laser) to the corresponding photosensitive sensors (the light-sensitive elements 41) along the horizontal direction, and after receiving the optical signals, the photosensitive sensors convert the optical signals into the electrical signals through a photoelectric effect, and send the electrical signals to the signal processing device 50.

[0034] In an alternative implementation of the present disclosure, the signal processing device 50 is specifically configured to determine a distance between a first light-sensitive element and an active light-sensitive element in the receiving component 40 in the vertical direction according to the electrical signal sent by each light-sensitive element 41, and determine the vertical distance D between the magnetron component 20 and the target 70 according to the distance between the first light-sensitive element and

the active light-sensitive element in the vertical direction and a prestored distance H between the first light-sensitive element and the target 70 in the vertical direction. The first light-sensitive element is the light-sensitive element 41 at the highest position, and the active light-sensitive element is the highest light-sensitive element 41 in the vertical direction that firstly receives the light beam and is lower than the light-sensitive elements 41 not receiving the light beams.

[0035] Specifically, the vertical distance satisfies the following relational expression:

$$D=H-h;$$

where D is the vertical distance between the target 70 and the magnetron component 20, H is the distance between the first light-sensitive element and the target 70 in the vertical direction, and h is the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction.

[0036] In the embodiment of the present disclosure, the signal processing device pre-stores the distance H between the first light-sensitive element at the highest position and the target 70 in the vertical direction, so that the vertical distance D between the magnetron component 20 and the target 70 may be obtained by calculation according to the distance in the vertical direction between the first light-sensitive element and the highest light-sensitive element 41 (i.e., the active light-sensitive element) lower than the magnetron component 20.

[0037] For example, in the state shown in FIG. 4, the light-sensitive element 41(1) is the first light-sensitive element at the highest position; and the light-sensitive element 41(i-1) and a certain number of the light-sensitive elements 41 above the light-sensitive element 41(i-1) do not receive the optical signals, and among the light-sensitive elements 41 which receive the optical signals and are lower than the light-sensitive element 41(i-1) and the certain number of the light-sensitive elements 41 thereabove, the light-sensitive element 41(i) is at the highest position, so the light-sensitive element 41(i) is taken as a current active light-sensitive element. A height of the current active light-sensitive element 41(i) corresponds to a height of the bottom of the magnetron component 20, so that the vertical distance D between the magnetron component 20 and the target 70 may be obtained by subtracting the distance between the first light-sensitive element (the light-sensitive element 41(1)) and the active light-sensitive element (the light-sensitive element 41(i)) in the vertical direction from the distance H between the first light-sensitive element and the target 70 in the vertical direction.

[0038] In an alternative implementation of the present disclosure, as shown in FIG. 3 and FIG. 4, the plurality of light-emitting elements 31 are disposed at equal intervals along the vertical direction (a distance between every two adjacent light-emitting elements 31 in the vertical direction is denoted by t), the plurality of light-sensitive elements 41 are disposed at equal intervals along the vertical direction (a distance between every two adjacent light-sensitive elements 41 in the vertical direction is also denoted by t) and are sequentially numbered along the vertical direction (for example, sequentially numbered from top to bottom); and the signal processing device 50 is configured to determine the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction according to a difference between a number of the active light-sensitive element and a number of the first light-sensitive element.

[0039] Specifically, the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction satisfies the following relational expression:

$$h=(i-1)\times t;$$

where h is the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction, i is the number of the active light-sensitive element, and t is the distance between every two adjacent light-sensitive elements 41 in the vertical direction.

[0040] As shown in FIG. 3 to FIG. 5, the plurality of light-sensitive elements 41 are disposed at equal intervals and sequentially numbered along the vertical direction. For example, n light-sensitive elements 41 may be numbered from 1 to n (that is, sequentially numbered from top to bottom as the light-sensitive element 41(1), the light-sensitive element 41(2) ... the light-sensitive element 41(n)). In such case, a distance between each light-sensitive element 41 and the first light-sensitive element (the light-sensitive element 41(1)) in the vertical direction may be obtained by calculation according to a difference between the number of each light-sensitive element 41 and the number of the first light-sensitive element. For example, as shown in FIG. 5, the number of the active light-sensitive element is 41(i), then the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction is $(i-1)t$, that is, the distance between the bottom of the magnetron component 20 and the first light-sensitive element in the vertical direction may be accordingly determined to be equal to $h=(i-1)t$. Then, the vertical distance D between the bottom of

the magnetron component 20 and the target 70 may be obtained by subtracting the determined distance h from the distance H between the first light-sensitive element (the light-sensitive element 41(1)) and the target 70 in the vertical direction, that is, by $D=H-(i-1)t$.

[0041] It should be noted that the number of the light-emitting elements 31 and the number of the light-sensitive elements 41 are such set that distribution ranges of the light-emitting elements 31 and the light-sensitive elements 41 along the vertical direction cover a range of raising and lowering movements of the magnetron component 20. For example, the height of the magnetron component 20 is x , an adjustment range of the height (i.e., a distance covered when the magnetron component 20 is moved between the highest point and the lowest point) is y , a product (i.e., a height distribution range of the light-sensitive elements 41) of the number of the light-sensitive elements 41 and the distance t between every two adjacent light-sensitive elements 41 is required to be greater than the range $x+y$ of raising and lowering movements of the magnetron component 20, that is, the number of the light-sensitive elements 41 is required to be greater than $(m+n)/t$.

[0042] In an alternative implementation of the present disclosure, the distance t between every two adjacent light-sensitive elements 41 in the vertical direction ranges from 0.08mm to 0.12mm. For example, the distance t between every two adjacent light-sensitive elements 41 in the vertical direction is 0.1mm, and in the state shown in FIG. 4, the vertical distance between the bottom of the magnetron component 20 and the target 70 is $D=H-0.1(i-1)$ (in unit of mm).

[0043] In an alternative implementation of the present disclosure, as shown in FIG. 2, the upper electrode case 60 includes an upper cover 61 and a mounting cylinder 62, the upper cover 61 is fixedly disposed at a top end of the mounting cylinder 62, the rotary drive component 10 passes through a through hole of the upper cover 61, and is connected to the magnetron component 20 in the mounting cylinder 62 for driving the magnetron component 20 to rotate, a bottom end of the mounting cylinder 62 is used for fixed arrangement of the target 70, two mounting through holes are formed on a cylinder wall of the mounting cylinder 62 and penetrate through the cylinder wall along a radial direction, and the two mounting through holes are arranged opposite to each other on two sides of an axis of the mounting cylinder 62, for example, the two mounting through holes are symmetrically disposed with respect to the axis of the mounting cylinder 62.

The emitting component 30 and the receiving component 40 are respectively disposed in the two mounting through holes. In practical installation and operating processes, the bottom end of the mounting cylinder 62 is used for fitting with an opening at a top of a cavity of the semiconductor process chamber, so as to expose the target 70 fixed at the bottom end of the mounting cylinder 62 to a gas environment inside the cavity while sealing the opening at the top of the cavity.

[0044] In an alternative implementation of the present disclosure, as shown in FIG. 2, the rotary drive component 10 includes a rotary mechanism 11, a rotating shaft 12, a pulley 13, and a belt drive device (not shown), the rotary mechanism 11 is fixedly disposed on the upper cover 61 for axial positioning of the rotating shaft 12 (that is, allowing the rotating shaft 12 to rotate around a rotation axis in the rotary mechanism 11 while keeping a height of the rotating shaft 12 unchanged), a top end of the rotating shaft 12 is coaxially connected to the pulley 13, and a bottom end of the rotating shaft 12 passes through the through hole of the upper cover 61 and is connected to the magnetron component 20 in the mounting cylinder 62. The belt drive device is connected to the pulley 13 through a belt and drives the pulley 13 through a friction force between the belt and the pulley 13 to drive the rotating shaft 12 and the magnetron component 20 fixed at the bottom end of the rotating shaft 12 to rotate together around the rotation axis.

[0045] In an alternative implementation of the present disclosure, the magnetron component 20 includes a magnetron mounting plate 21 and a magnetron part 22 including a plurality of magnetrons, and the mounting plate 21 is used for fixed connection of the bottom end of the rotating shaft 12 with the magnetron part 22.

[0046] In a preferred implementation of the present disclosure, the signal processing device 50 is further configured to determine a lifting height of the magnetron component 20 according to a difference between a number of a corresponding active light-sensitive element after the height of the magnetron component 20 is changed and a number of a corresponding active light-sensitive element before the height of the magnetron component 20 is changed.

[0047] Specifically, the lifting height of the magnetron component satisfies the following relational expression:

$$L=(m-n)\times t;$$

where L is the lifting height of the magnetron component 20, m is the number of the corresponding active light-sensitive element after the height of the magnetron component 20 is changed, n is the number of the corresponding active light-sensitive element before the height of the magnetron component 20 is changed, and t is the distance between every two adjacent light-sensitive elements 41 in the vertical direction. [0048] For example, after the height of the magnetron component 20 is changed from the state shown in FIG. 4 to the state shown in FIG. 6, the light-sensitive element 41(j) is the light-sensitive element 41 in the vertical direction which firstly receives the light beam and is lower than the light-sensitive elements not receiving the light beams (the light-sensitive element 41(j-1) and a certain number of light-sensitive elements 41 thereabove), that is, the light-sensitive element 41(j) is a current active light-sensitive element. The signal processing device 50 may determine a height difference between the two active light-sensitive elements according to a difference (j-i) between the number j of the current active light-sensitive element and the number i of the active light-sensitive element before the height of the magnetron component 20 is changed, that is, the height difference is a product of the number difference (j-i) and the distance t between every two adjacent light-sensitive elements, and then further determine the lifting height L of the magnetron component 20 by $L=(j-i) \times t$.

[0049] In the embodiment of the present disclosure, the signal processing device 50 can determine the lifting height of the magnetron component 20 according to the difference between the number of the active light-sensitive element before the height of the magnetron component 20 is changed and the number of the light-sensitive element after the height of the magnetron component 20 is changed. Thus, in a process which requires adjustment to the height of the magnetron component 20, whether an adjusted height of the magnetron component 20 reaches a target value can be verified with the signal processing device 50 in real time, thereby ensuring an adjustment effect of semiconductor process parameters.

[0050] In a second aspect of the present disclosure, there is provided a semiconductor process chamber. As shown in FIG. 7, the semiconductor process chamber includes the upper electrode structure provided in the embodiment of the present disclosure.

[0051] In some alternative embodiments, the semiconductor process chamber further includes a control device configured to give an alarm when a vertical distance D exceeds a preset distance range.

[0052] In the present disclosure, the upper electrode structure of the semiconductor process chamber includes the emitting component 30 and the receiving component 40 which are disposed on two sides of the magnetron component 20. The emitting component 30 is configured to transmit a plurality of optical signals to the receiving component 40, and the plurality of optical signals are a plurality of light beams that horizontally propagate and are arranged at intervals along a vertical direction. The magnetron component 20 is located between the emitting component 30 and the receiving component 40, so that the magnetron component 20 can block the light beams emitted by the emitting component 30 within a corresponding height range, and the receiving component 40 cannot receive the light beams within the height range. Thus, the signal processing device 50 can determine the vertical distance D between the magnetron component 20 and the target 70 in real time according to a situation of reception of the light beams by the receiving component 40, which improves efficiency of determining a height of the magnetron component 20. Moreover, after the height of the magnetron component 20 is changed in a semiconductor process (for example, the height of the magnetron component 20 needs to be adjusted in some processes, or the magnetron component 20 is displaced due to poor fixation), the signal processing device 50 can also monitor a position of the magnetron component 20 on time after the magnetron component 20 is raised or lowered, which ensures accuracy of the position of the magnetron component 20, thereby improving a semiconductor process effect.

[0053] Furthermore, the control device may monitor, in real time, the vertical distance D determined by the signal processing device 50 during a semiconductor process, and give an alarm when the vertical distance D exceeds the preset distance range (that is, the vertical distance D is less than a minimum critical value of the preset distance range or greater than a maximum critical value of the preset distance range), so as to inform an operator of an abnormal condition of the machine on time, thereby ensuring safety of the semiconductor process

[0054] In an alternative implementation of the present disclosure, as shown in FIG. 7, the semiconductor process chamber further includes a base 1, a chamber 2, a liner 3, a connecting piece 4, and a power supply 9. The base 1 and the liner 3 are both disposed in the chamber 2, the base 1 is used for placement of a wafer, and the liner 3 is configured to prevent atoms of a target from being deposited on an inner wall of the chamber 2 during a sputtering process, so as to ensure cleanliness of the chamber. The upper

electrode structure is fixedly connected to the chamber 2 through the connecting piece 4, so as to seal an opening at a top of the chamber 2.

[0055] In a PVD process, a wafer is first placed on the base 1, the power supply 9 applies a voltage to the target 70, an inert gas (e.g., argon (Ar)) is then introduced into the chamber 2 from a gas source 7, the inert gas is ionized at a high voltage, and the ionized atoms bombard the target 70 under the action of a magnetic field generated by the magnetron component 20, so that atoms on a surface of the target 70 fall off and are deposited on a surface of the wafer on the base 1, thereby achieving coating by magnetron sputtering deposition.

[0056] It should be understood that the above implementations are merely exemplary implementations adopted to illustrate the principle of the present disclosure, and the present disclosure is not limited thereto. Various modifications and improvements can be made by those of ordinary skill in the art without departing from the spirit and essence of the present disclosure, and those modifications and improvements are also considered to fall within the scope of the present disclosure.

What is claimed is:

1. An upper electrode structure applied to a semiconductor process chamber, comprising a magnetron component, an emitting component, a receiving component, a target, and a signal processing device; wherein

the magnetron component is located above the target and is configured to provide a magnetic field for an interior of the semiconductor process chamber;

the emitting component and the receiving component are disposed opposite to each other on two sides of the magnetron component along a horizontal direction;

the emitting component is configured to transmit a plurality of optical signals to the receiving component, and the plurality of optical signals are a plurality of light beams that horizontally propagate and are arranged at intervals along a vertical direction;

the receiving component is configured to receive the plurality of optical signals, convert the plurality of optical signals into electrical signals, and send the electrical signals to the signal processing device; and

the signal processing device is configured to determine a vertical distance between the magnetron component and the target according to the electrical signals.

2. The upper electrode structure of claim 1, wherein the emitting component comprises a plurality of light-emitting elements disposed at intervals along the vertical direction, the receiving component comprises a plurality of light-sensitive elements disposed at intervals along the vertical direction, the plurality of light-emitting elements are configured to transmit the optical signals to the plurality of light-sensitive elements in a one-to-one correspondence manner, and the plurality of light-sensitive elements are configured to receive the optical signals transmitted by the corresponding light-emitting elements, convert the optical signals into the electrical signals, and send the electrical signals to the signal processing device.

3. The upper electrode structure of claim 2, wherein the signal processing device is configured to determine a distance between a first light-sensitive element and an active light-sensitive element in the vertical direction according to the electrical signals sent by the light-sensitive elements, and determine the vertical

distance between the magnetron component and the target according to the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction and a prestored distance between the first light-sensitive element and the target in the vertical direction; wherein

the first light-sensitive element is a light-sensitive element at a highest position, and the active light-sensitive element is a light-sensitive element in the vertical direction that firstly receives an electrical signal and is lower than the light-sensitive elements not receiving the electrical signals.

4. The upper electrode structure of claim 3, wherein the vertical distance satisfies a following relational expression:

$$D=H-h;$$

where D is the vertical distance between the target and the magnetron component, H is the distance between the first light-sensitive element and the target in the vertical direction, and h is the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction.

5. The upper electrode structure of claim 3, wherein the plurality of light-emitting elements are disposed at equal intervals along the vertical direction, the plurality of light-sensitive elements are disposed at equal intervals along the vertical direction and are sequentially numbered along the vertical direction; and the signal processing device is configured to determine the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction according to a difference between a number of the active light-sensitive element and a number of the first light-sensitive element.

6. The upper electrode structure of claim 5, wherein the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction satisfies a following relational expression:

$$h=(i-1)\times t;$$

where h is the distance between the first light-sensitive element and the active light-sensitive element in the vertical direction, i is the number of the active light-sensitive element, and t is a distance between every two adjacent light-sensitive

elements in the vertical direction.

7. The upper electrode structure of claim 5, wherein the signal processing device is further configured to determine a lifting height of the magnetron component according to a difference between a number of a corresponding active light-sensitive element after a height of the magnetron component is changed and a number of a corresponding active light-sensitive element before the height of the magnetron component is changed.

8. The upper electrode structure of claim 7, wherein the lifting height of the magnetron component satisfies a following relational expression:

$$L=(m-n)\times t;$$

where L is the lifting height of the magnetron component, m is the number of the corresponding active light-sensitive element after the height of the magnetron component is changed, n is the number of the corresponding active light-sensitive element before the height of the magnetron component is changed, and t is a distance between every two adjacent light-sensitive elements in the vertical direction.

9. The upper electrode structure of claim 1, further comprising an upper cover, a mounting cylinder, and a rotary drive component; wherein

the upper cover is fixedly disposed at a top end of the mounting cylinder, and the rotary drive component passes through a through hole of the upper cover, and is connected to the magnetron component in the mounting cylinder for driving the magnetron component to rotate; and

a bottom end of the mounting cylinder is used for fixed arrangement of the target, two mounting through holes are formed on a cylinder wall of the mounting cylinder and penetrate through the cylinder wall along a radial direction, the two mounting through holes are arranged opposite to each other on two sides of an axis of the mounting cylinder, and the emitting component and the receiving component are respectively disposed in the two mounting through holes.

10. A semiconductor process chamber, comprising the upper electrode structure of any one of claims 1 to 9.

11. The semiconductor process chamber of claim 10, further comprising a control device, which is configured to give an alarm when the vertical distance exceeds a preset distance range.