

HEATING DEVICE AND SEMICONDUCTOR PROCESSING APPARATUS

FIELD OF TECHNOLOGY

[0001] The present disclosure relates to the technical field of semiconductor manufacturing equipment, and particularly relates to a heating device and a semiconductor processing apparatus.

BACKGROUND

[0002] Chemical Vapor Deposition (CVD) silicon epitaxy is a process of growing a silicon film on the surface of a silicon-based substrate (e.g., a wafer) using CVD technology. Specifically, reaction gases are controlled to flow over the heated wafer, where the reactants undergo a chemical reaction on the wafer surface to generate elemental silicon, thereby forming a silicon film of elemental silicon on the wafer surface.

[0003] A schematic structural diagram of an existing CVD epitaxial apparatus is shown in FIG. 1, in which a top plate and a bottom plate of a process chamber 10a are made of transparent materials, and an upper heating device 20a and a lower heating device 30a providing on infrared light heating are arranged on the upper side and the lower side of the process chamber 10a respectively. The substrate 101a is placed on a susceptor 11a in the process chamber 10a; an upper heating device 20a directly heats the surface of the substrate 101a, and the lower heating device 30a indirectly heats the substrate 101a by heating the susceptor 11a.

[0004] The temperature distribution on the surface of the substrate 101a has a significant influence on the thickness, resistivity, and slip line distribution of the silicon epitaxy film. In regions with higher temperature, the growth rate of the epitaxial layer is higher, and the epitaxial layer is relatively thicker. During heating of the substrate 101a, since the lower heating device 30a directly heats the susceptor 11a and indirectly heats the substrate 101a through the heat conduction of the susceptor 11a,

the heat is already relatively uniformly distributed during heat conduction. In contrast, the upper heating device 20a irradiates the substrate 101a directly, and the light irradiation distribution of the upper heating device 20a plays a dominant role in the temperature distribution on the surface of the substrate 101a.

[0005] The conventional upper heating device 20a suffers from problems of large local temperature differences and non-uniform temperature field on the surface of the substrate 101a.

SUMMARY

[0006] The present disclosure provides a heating device and a semiconductor processing apparatus, which can solve the problem of non-uniform temperature field generated by the existing upper heating device.

[0007] In a first aspect, an embodiment of the present disclosure provides a heating device for heating a susceptor in a semiconductor chamber, the heating device is located on one side of the susceptor in a perpendicular direction, a central region and multiple annular regions surrounding the central region all of which are coaxial with the central axis of the susceptor, as parts of the heating device;

[0008] wherein the heating device comprises, in each of the annular regions, multiple heating lamps evenly disposed along a circumferential direction of the annular region, and an annular reflective plate disposed on a side of the multiple heating lamps away from the susceptor in each of the annular regions; and a reflective assembly disposed on a side of each of the annular regions adjacent to the central region; wherein the reflective assembly comprises multiple reflective plates in one-to-one correspondence with the heating lamps in the corresponding annular region;

[0009] wherein the reflective plates extend from the annular reflective plate toward the susceptor so as to confine the light emitted from the corresponding heating lamp to irradiate within a preset area of the susceptor;

[0010] wherein the reflective assembly enables the multiple heating lamps to respectively irradiate preset areas of the susceptor in different radial ranges; and wherein a central axis of the annular region is coaxial with a central axis of the susceptor.

[0011] In some embodiments, each of the reflective plates in the reflective assembly is parallel to a central axis of the susceptor; or,

[0012] an included angle between each of the reflective plates and the central axis of the susceptor is the same.

[0013] In some embodiments, the heating lamps belonging to the same annular region are of the same height;

[0014] wherein a distance between one end of the reflective plate adjacent to the susceptor and the susceptor is a first height of the reflective plate, and first heights of the reflective plates belonging to the same reflective assembly are not completely the same.

[0015] In some embodiments, in the same reflective assembly, the first heights of any two adjacent reflective plates are different.

[0016] In some embodiments, the heating device further comprises an actuator configured to adjust lifting of each of the reflective plates.

[0017] In some embodiments, the heating lamps belonging to the same annular region are of the same height;

[0018] wherein a distance between one end of the reflective plate adjacent to the susceptor and the susceptor is a first height of the reflective plate, and first heights of the reflective plates belonging to the same reflective assembly are the same.

[0019] wherein in each reflective assembly, at least a part of the reflective plates are provided with light-transmitting holes, and a distance between each of the light-

transmitting holes and the susceptor is less than a distance between the corresponding heating lamp and the susceptor.

[0020] In some embodiments, in each reflective assembly, two adjacent light-transmitting holes have different distances from the susceptor.

[0021] In some embodiments, in two adjacent annular regions, along the same radial direction, a distance of the heating lamp in the outer annular region from the susceptor is less than a distance of the heating lamp in the inner annular region from the susceptor.

[0022] In some embodiments, in two adjacent annular regions, along the same radial direction, a first height of the reflective plate in the outer annular region is less than a first height of the reflective plate in the inner annular region.

[0023] In some embodiments, in each of the annular regions, the reflective assembly is symmetrical with respect to a center of the annular region.

[0024] In some embodiments, the heating device further comprises a circular reflective plate disposed in the central region, and the reflective assembly in the innermost annular region is arranged around the circular reflective plate;

[0025] a distance of the circular reflective plate from the susceptor is greater than the first height of any of the reflective plates in the reflective assembly disposed in the innermost annular region.

[0026] In a second aspect, an embodiment of the present disclosure provides a semiconductor processing apparatus, comprising a semiconductor chamber, and further comprising a heating device as described in each of the above embodiments disposed above and/or below the semiconductor chamber, wherein the heating device is configured to heat a susceptor within the semiconductor chamber during processing.

[0027] As described above, in the heating device of the present disclosure, the annular reflective plate is arranged on a side of the heating lamp far away from the susceptor, and the reflective assembly is arranged on a side of the annular region adjacent to the central region. Under the confinement and reflection of the annular reflective plate and the reflective assembly, the heating lamps irradiate light toward the susceptor to heat the susceptor. The light emitted downward from the entire heating device tends to form multiple light rings, thereby enabling independent control of the light intensity at different radial positions. Since the reflective assembly comprises multiple reflective plates respectively corresponding to the heating lamps in the corresponding annular region, and the reflective plates extend from the annular reflective plate toward the susceptor, each of the reflective plates confines the light emitted from the corresponding heating lamp to irradiate within a preset area of the susceptor. As a result, the heating lamps in the same annular region can irradiate different radial positions, thereby avoiding concentrated irradiation on the same region and a cliff-like distribution of light intensity along the radial direction. Accordingly, a gradual variation of irradiation intensity can be achieved, and the heating uniformity can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The accompanying drawings herein, which are incorporated into and constitute a part of the specification, illustrate embodiments consistent with the present disclosure and, together with the specification, serve to explain the principles of the present disclosure. In order to more clearly illustrate the technical solutions of the embodiments of the present disclosure, the drawings that need to be used in the description of the embodiments will be briefly introduced below. It will be apparent to those of ordinary skill in the art that, without creative efforts, other drawings may also be obtained based on these drawings.

[0029] FIG. 1 is a schematic structural diagram of a conventional CVD epitaxial apparatus;

[0030] FIG. 2 is a schematic structural diagram (bottom view) of an upper heating device according to a reference example of the present disclosure;

[0031] FIG. 3 is a schematic structural diagram (bottom view) of a heating device according to an embodiment of the present disclosure;

[0032] FIG. 4 is a developed cross-sectional view of the reflective assembly corresponding to the outer-ring heating lamp in FIG. 3;

[0033] FIG. 5 is a schematic side view of the structure in FIG. 3;

[0034] FIG. 6 is a schematic structural diagram of a semiconductor processing apparatus according to an embodiment of the present disclosure.

[0035] FIG. 7 is a schematic structural diagram showing notches of different depths provided on reflective plates according to an embodiment of the present disclosure;

[0036] FIG. 8 is a schematic top view of a reflective assembly according to an embodiment of the present disclosure.

[0037] FIG. 9 is a schematic structural diagram in which light-transmitting holes of different heights are provided on reflective plates according to an embodiment of the present disclosure;

[0038] FIG. 10 is a developed cross-sectional view of a reflective assembly corresponding to the outer-ring heating lamp in FIG. 5.

[0039] The objectives, functional features, and advantages of the present disclosure will be further explained in conjunction with the embodiments and with reference to the accompanying drawings. Through the above drawings, explicit embodiments of the present disclosure are illustrated, and more detailed descriptions will be provided hereinafter. These drawings and the accompanying description are not intended to limit the scope of the inventive concept of the present disclosure in any way, but rather to illustrate the concept of the present disclosure to those skilled in the art with

reference to specific embodiments.

DETAILED DESCRIPTION

[0040] Exemplary embodiments are described herein in detail and are illustrated in the accompanying drawings. In the following description with reference to the drawings, unless otherwise indicated, the same reference numerals in different drawings denote the same or similar elements. The embodiments described in the following exemplary embodiments do not represent all embodiments consistent with the present disclosure. Rather, they are merely examples of devices and methods consistent with some aspects of the present disclosure as defined in the appended claims.

[0041] It should be noted that, herein, the terms "comprising," "including," or any other variation thereof are intended to encompass a non-exclusive inclusion such that a process, method, article, or apparatus that comprises a series of elements not only includes those elements but may also include other elements not explicitly listed, or elements inherent to such process, method, article, or apparatus. Without further limitations, an element defined by the sentence "comprising a..." does not exclude the presence of another identical element in a process, method, article, or device comprising the element. In addition, components, features, and elements with the same names in different embodiments of the present disclosure may have the same meaning or different meanings, and the specific meanings thereof need to be determined by their interpretation in the specific embodiment or further combined with the context in the specific embodiment.

[0042] It should be further understood that the terms "comprise" and "comprise" indicate the existence of the described features, steps, operations, elements, components, items, categories, and/or groups, but do not exclude the existence, presence, or addition of one or more other features, steps, operations, elements,

components, items, categories, and/or groups. As used herein, the terms "or," "and/or," "comprising at least one of the following," and the like may be construed as inclusive, or mean any one or any combination. For example, "comprising at least one of: A, B, C" means "any one of: A; B; C; A and B; A and C; B and C; A and B and C ", as another example, "A, B or C "or" A, B and/or C "means" any of the following: A; B; C; A and B; A and C; B and C; A and B and C ". Exceptions to this definition apply only when combinations of elements, functions, steps, or operations are inherently paradoxical in some way.

[0043] It should be understood that although the terms "first," "second," "third," and the like may be employed herein to describe various information, such information should not be limited to these terms. These terms are only used to distinguish the same type from one another. For example, without departing from the scope of the present disclosure, the first information may also be referred to as the second information, and similarly, the second information may also be referred to as the first information. As used herein, depending on the context, the singular forms "a," "an," and "the" are intended to comprise the plural forms as well, unless the context clearly indicates otherwise.

[0044] It should be understood that the terms "top," "bottom," "upper," "lower," "vertical," "horizontal," and the like indicating orientations or positional relationships are based on the orientations or positional relationships shown in the drawings, and are merely for facilitating the description of the present disclosure and simplifying the description, rather than indicating or implying that the referred device must have a specific orientation or be constructed and operated in a specific orientation. Therefore, such expressions should not be construed as limiting the present application.

[0045] For convenience of description, in the following embodiments, orthogonal spaces formed by a horizontal plane and a vertical direction are described as

examples, and this prerequisite should not be understood as a limitation of the present disclosure.

[0046] Please refer to FIG. 2, which is a schematic structural diagram (bottom view) of an upper heating device 20a according to a reference example of the present disclosure. Please also refer to FIG. 1, the upper heating device 20a comprises multiple heating lamps 21a and reflective plates 22a disposed above and around the multiple heating lamps 21a. The reflective plates 22a disposed above the heating lamps 21a are parallel to the susceptor 11a of the process chamber 10a. The reflective plates 22a can reflect the light emitted from the heating lamps 21a toward the reflective plates 22a onto the surface of the substrate 101a, thereby enhancing heating efficiency and optimize light utilization. Since the reflective plates 22a enhance the light intensity at certain radial positions due to reflection while weakening the light intensity at other radial positions due to shielding, the above phenomenon results in significant differences in light intensity on both sides of a specific radial position. This, in turn, causes large local temperature differences and non-uniformity in the temperature field on the surface of the substrate 101a.

[0047] In addition, all the heating lamps 21a may be arranged in a circle, and for every three heating lamps 21a, the reflective surface of the reflective plate 22a is provided with an inclined surface structure. This inclined surface structure enables the reflected light of a corresponding heating lamp 21a (distinguished from other heating lamps by hatching in the drawings) to be directed toward the central region of the substrate 101a, thereby adjusting the light distribution.

[0048] In the upper heating device 20a, only the reflected light of the heating lamp 21a corresponding to the inclined surface structure can be adjusted. This solution can only make slight adjustments to the temperature field and covers a relatively narrow process range. In view of this, the present disclosure provides a heating device and a semiconductor processing apparatus having an adjustable temperature field distribution.

[0049] Referring to FIGs. 3 to 5, FIG. 3 is a schematic structural diagram (bottom view) of a heating device according to an embodiment of the present disclosure, FIG. 4 is a developed cross-sectional view of the reflective assembly corresponding to the outer-ring heating lamp in FIG. 3, and FIG. 5 is a schematic side view of the structure in FIG. 3. The heating device is configured to heat the susceptor in the semiconductor chamber, and when mounted on the semiconductor chamber, the heating device is disposed on one side of the susceptor in the perpendicular direction. For example, referring also to FIG. 6, the heating device may be disposed outside the semiconductor chamber 100 or inside the semiconductor chamber 100. The heating device may be disposed directly above the susceptor 130 or directly below the susceptor 130, or may include two heating devices respectively disposed above and below the susceptor 130.

[0050] The heating device has a central region 301 and multiple annular regions 302 sequentially surrounding the central region 301 outward from the central region, all of which are coaxial with the central axis of the susceptor 130, as parts of the heating device; wherein, the heating device comprises, in each annular region 302, multiple heating lamps 40 evenly distributed circumferentially along the annular region 302, and an annular reflective plate 10 disposed on a side of the heating lamps 40 away from the susceptor 130. Specifically, if the heating device is disposed directly above the susceptor 130, the annular reflective plate 10 is disposed above the heating lamps 40; If the heating device is disposed directly below the susceptor 130, the annular reflective plate 10 is disposed below the heating lamps 40.

[0051] The heating device further comprises a reflective assembly 30 disposed on the side of each annular region 302 near the central region 301; the reflective assembly 30 comprises multiple reflective plates 31 that respectively correspond to multiple heating lamps 40 in a corresponding annular region 302; each of the reflective plates 31 extend from the annular reflective plate 10 toward the susceptor 130 to confine the light emitted from the corresponding heating lamp 40 to irradiate

within a preset area of the susceptor 130; the reflective assembly 30 enables the heating lamps 40 to respectively irradiate preset areas of the susceptor 130 in different radial ranges; wherein the central axis of the annular region 302 is coaxial with the central axis of the susceptor 130.

[0052] Taking two annular regions 302 (302A and 302B) as an example, which are respectively an outer-ring annular region 302A and an inner-ring annular region 302B, multiple heating lamps 40 are respectively provided in the two annular regions 302, for example, 32 heating lamps 40A may be evenly distributed in the outer-ring annular region 302A, and 8 heating lamps 40B may be evenly distributed in the inner-ring annular region 302B. In specific applications, the number of heating lamps 40 provided in each annular region 302 is set according to the heating requirements. As one example, the heating lamps 40 may be infrared heating lamps.

[0053] Correspondingly, two annular reflective plates 10 may be provided, namely, an annular reflective plate 10A corresponding to the outer-ring annular region 302A and an annular reflective plate 10B corresponding to the inner-ring annular region 302B. The annular reflective plate 10A on the side of the heating lamp 40A away from the susceptor 130 can reflect the light of the heating lamp 40A to the corresponding region on the susceptor 130, and the annular reflective plate 10B on the side of the heating lamp 40B away from the susceptor 130 can reflect the light of the heating lamp 40B to the corresponding region on the susceptor 130.

[0054] Correspondingly, two reflective assemblies 30 are also provided, namely, a reflective assembly 30A corresponding to the outer-ring annular region 302A and a reflective assembly 30B corresponding to the inner-ring annular region 302B, and the reflective assembly 30B is provided on the side of the inner-ring annular region 302B adjacent to the central region 301. The reflective assembly 30A is disposed on the side of the outer-ring annular region 302A adjacent to the central region 301.

[0055] The reflective assembly 30 comprises multiple reflective plates 31 in one-to-one correspondence with multiple heating lamps 40 in a corresponding annular region 302. For example, when the outer-ring annular region 302A is provided with 32 heating lamps 40A, the reflective assembly 30A comprises 32 reflective plates 31, and when the inner-ring annular region 302B is provided with 8 heating lamps 40B, the reflective assembly 30B comprises 8 reflective plates 31. The reflective plates 31 extend from the annular reflective plate 10 toward the susceptor 130 to confine the light emitted from the corresponding heating lamps 40 to irradiate within a preset area of the susceptor 130. That is, the reflective plates 31 can confine the irradiation range of the heating lamps 40 to the central region of the susceptor 130 from the inner side, so that ultimately, the light from multiple heating lamps 40 is respectively irradiated within different radial ranges of the susceptor 130.

[0056] The working principle of the heating device of this embodiment is as follows: the annular reflective plate 10 is arranged on the side of the heating lamps 40 away from the susceptor 130, the reflective assembly 30 is arranged on the side of the annular region 302 adjacent to the central region 301. Under the confinement and reflection of the annular reflective plate 10 and the reflective assembly 30, the heating lamps 40 irradiate light toward the susceptor 130 to heat the susceptor 130. The light emitted downward from the entire heating device tends to form multiple light rings, thereby enabling independent control of the light intensity at different radial positions. Since the reflective assembly 30 comprises multiple reflective plates 31 respectively corresponding to the heating lamps 40 in the corresponding annular region 302, and the reflective plates 31 extend from the annular reflective plate 10 toward the susceptor 130, each of the reflective plates 31 confines light emitted from the corresponding heating lamps 40 to irradiate within a preset area of the susceptor 130.

[0057] As a result, the heating lamps 40 in the same annular region can irradiate different radial positions, thereby avoiding concentrated irradiation on the same region and an abrupt distribution of light intensity along the radial direction.

[0058] Accordingly, a gradual variation of irradiation intensity can be achieved, thereby improving heating uniformity.

[0059] It will be appreciated that for the outermost annular region 302, an additional reflective assembly 30 may be disposed around its outer diameter to confine light from the heating lamps 40 within the heating device.

[0060] In this embodiment, the angle of the reflective assembly 30 in the vertical direction is not limited. As some examples, each of the reflective plates 31 in the reflective assembly 30 may be parallel to the central axis of the susceptor 130, or may have the same angle with the central axis of the susceptor 130, for example, the reflective plates 31 are inclined by a preset angle (such as 10°) from top to bottom to the central axis of the susceptor 130, or are inclined by a preset angle away from the central axis of the susceptor 130. By combining the setting of the length of the reflective plates 31 in the vertical direction, the setting of the installation height of the heating lamps 40, and other relevant settings, it is possible to enable the heating lamps 40 in the same circle to irradiate areas at different radial ranges of the susceptor 130. The present disclosure will be described in further detail below with specific embodiments.

[0061] In one embodiment, with continued reference to FIGs. 4 and 5, the heat lamps 40 belonging to the same annular region 302 are of the same height. When the heating device is attached to the semiconductor chamber, the distance between one end of the reflective plate 31 adjacent to the susceptor 130 and the susceptor 130 is a first height H of the reflective plate 31, and first heights H of the reflective plates 31 belonging to the same reflection module 30 are not completely the same. For example, in FIG. 4, first heights of the reflective plate 31B and the reflective plate

31A differ by H_0 , so that a notch 311 is formed on the reflective assembly 30, and the heating lamp 40 corresponding to the reflective plate 31A can irradiate positions at different radial positions of the susceptor 130 through the notch 311, thereby realizing the gradual change of light intensity along the radius. By setting the first height H of each of the reflective plates 31, multiple notches 311 may be formed so that the reflective assembly 30 takes on a sawtooth structure as shown in FIG. 4. For example, in the same annular region 302, every other heating lamp 40A is provided with a notch 311, and the notch 311 is disposed on the same radius as the projection of the corresponding heating lamp 40A on the annular region 302. As the depth dimension H_0 of the notch 311 varies, the irradiation radius also varies. The provision of notches 311 on the reflective plates 31 can broaden the irradiation radius range of the heating lamps 40A, thereby realizing a gradual change in irradiation intensity and improving heating uniformity.

[0062] It should be noted that the reflective assembly 30 may be formed as an integrated structure, or may be assembled by sequentially splicing multiple reflective plates 31 together, as shown in FIG. 8. The notches 311 can be formed by setting the lengths of two adjacent reflective plates 31 in the vertical direction to be unequal, as shown in FIG. 4. The embodiments of the present disclosure do not specifically limit the detailed forming method of the reflective assembly 30.

[0063] It should be emphasized that by setting the shape and height of the reflective plates 31, the depth H_0 of the notches 311 may vary, and the position of the notches 311 appearing on the reflective assembly 30 may be random and not have periodicity. Moreover, the shape of the notches 311 is not limited to the rectangular shape shown in the figure, but may also be triangular, arcuate, or a combination of different shapes, and so forth.

[0064] For example, in the same reflective assembly 30, any two adjacent reflective plates 31 may have different first heights H , thereby forming a regular sawtooth structure that improves the heating uniformity. In addition, in each annular region

302, the reflective assembly 30 is preferably symmetrical with respect to the center of the annular region 302, so that the heating lamps 40 disposed in coaxial positions can heat the susceptor 130 over the same radial range, so that the illumination range can be symmetrically adjusted to enhance the uniformity of the temperature field.

[0065] As an example, in two adjacent annular regions 302, along the same radial direction, the first height of the reflective plate 31 of the outer annular region 302 is less than the first height of the reflective plate 31 of the inner annular region 302. This configuration can prevent the heating lamps 40 from diverging to the outside, thereby reducing the heating efficiency.

[0066] In one embodiment, referring to FIG. 5, in two adjacent annular regions 302, along the same radial direction, the distance L of the heating lamp 40 of the outer annular region 302 from the susceptor 130 is less than the distance L of the heating lamp 40 of the inner annular region 302 from the susceptor 130. Since a position adjacent to the center of the susceptor 130 is irradiated by more heating lamps 40, by arranging the inner heating lamps 40 farther away from the susceptor 130, the aforementioned non-uniform heating can be balanced, thereby improving the heating uniformity of the susceptor 130.

[0067] In one embodiment, please continue referring to FIGs. 3 and 5, the heating device may further comprise a circular reflective plate 20 disposed in the central region 301. The reflective assembly 30 of the innermost annular region 302 is disposed around the circular reflective plate 20, and the distance S between the circular reflective plate 20 and the susceptor 130 is greater than the first height H of any of the reflective plates 31 in the reflective assembly 30 of the innermost annular region 302. By providing the circular reflective plate 20 at a position higher than any of the reflective plates 31 in the reflective assembly 30 disposed in the innermost annular region 302, it is possible to reduce blockage of irradiation from the heating lamps in the inner annular region 302 by the circular reflective plate 20.

[0068] For convenience of description, please refer to FIGs. 6 and 7, FIG. 6 is a schematic structural diagram of a semiconductor processing apparatus according to an embodiment of the present disclosure, and FIG. 7 is a schematic structural diagram showing notches of different depths provided on a reflective plate according to an embodiment of the present disclosure, and the heating device provided by the present disclosure is applied to the semiconductor processing apparatus. Taking the case where the heating device is disposed above the susceptor 130 as an example, a surface disposed at a preset distance L_0 below the annular reflective plate 10 is defined as the target plane 102. In practice, the target plane 102 may correspond to the top surface of the element to be heated (such as a substrate). That is, after the element to be heated is loaded on the susceptor 130, the distance between the top surface of the element to be heated and the bottom surface of the annular reflective plate 10 is L_0 . A point on the target plane 102 directly opposite the center of the annular region 302 is defined as a center point O, and the intersection of the light beam emitted from a heating lamp 40 through its corresponding notch 311 with the target plane 102 is defined as a target point A. As some examples, the depth of at least one notch 311 may be such that the projection B of the heating lamp 40 on the target plane 102 and the target point A are disposed on the same side of the center point O, as shown in view (a) of FIG. 7. As described above, the notches 311 are preferably arranged in symmetrical pairs with respect to the center point O. FIG. 7 illustrates two symmetrically positioned heating lamps 40 emitting light rays onto the target plane 102 through their respective notches 311. By means of these notches 311, the irradiation radius of the corresponding heating lamps 40 can be extended toward the center point O, preventing all the light rays from being concentrated at the same radius and thereby enabling a gradual variation in illumination intensity.

[0069] As another example, the depth of at least one notch 311 may be such that the projection B of the heating lamp 40 on the target plane 102 and the target point A lie on opposite sides of the center point O, as shown in view (c) of FIG. 7. Similarly, FIG. 7 shows two symmetrically positioned heating lamps 40 emitting light rays

through their respective notches 311. With deeper notches 311, the heating lamps 40 can irradiate to the opposite side of the center point O, thereby providing a larger irradiation radius and achieving a gradual change in illumination intensity.

[0070] As a further example, the depth of at least one notch 311 may be such that the target point A coincides with the center point O, as shown in view (b) of FIG. 7. Likewise, FIG. 7 shows two symmetrically positioned heating lamps 40 emitting light rays through their respective notches 311. The heating lamps 40 just irradiate the center point O through the corresponding notches 311, that is, the target point A coincides with the center point O.

[0071] In practical applications, the depth of the notches 311 may be selected from the three configurations corresponding to views a, b, and c in FIG. 7. One of the configurations may be selected, or two or three of them may be used in combination. The temperature field can be regulated by controlling the on/off state and power of the heating lamps 40 corresponding to different notches 311.

[0072] In one embodiment, referring to FIG. 6, the heights of the heating lamps 40 within the same annular region 302 are the same, while the first heights H of the reflective plates 31 in the same reflective assembly 30 are not the same. The heating device may further comprise drivers 50 for adjusting the lifting and lowering of each of the reflective plates 31. For example, the drivers 50 may be motors. The drivers 50 may be provided in one-to-one correspondence with the reflective plates 31, or a single driver 50 may control the lifting and lowering of two heating lamps 40 positioned symmetrically to the susceptor 130. When a significant adjustment of the temperature field is required, the drivers 50 can adjust the lifting and lowering of each of the reflective plates 31 to achieve a larger process coverage area.

[0073] Further, referring to FIG. 6, the heating device may also include a controller 60. The controller 60 can individually control the on/off state and the heating power

of each of the heating lamps 40, thereby allowing the temperature field to be adjusted over a wider range.

[0074] In one embodiment, light-transmitting holes 312 may also be provided on the reflective plates 31 to change the radial irradiation range of the heating lamp. Referring to FIGs. 9 and 10, FIG. 9 is a schematic structural diagram in which light-transmitting holes of different heights are provided on the reflective plates provided by an embodiment of the present disclosure, and FIG. 10 is an expanded cross-sectional view of a reflective assembly corresponding to an outer annular region in FIG. 5. In this scheme, the heights of the heating lamps 40 belonging to the same annular region 302 are the same, and the first heights H of the reflective plates 31 belonging to the same reflective assembly 30 are the same, so that the manufacturing process of the reflective assembly 30 can be simplified. In each reflective assembly 30, at least some of the reflective plates 31 are provided with light-transmitting holes 312, and the distance between the light-transmitting holes 312 and the susceptor 130 is less than the distance between the corresponding heating lamp 40 and the susceptor 130, ensuring that the light from the heating lamps 40 can pass through the corresponding light-transmitting holes 312 to irradiate downward and heat the susceptor 130.

[0075] In FIG. 9, from view (a) to view (c), compared with view (a), after the light-transmitting holes 312A and 312B are provided, the heating lamps 40 can irradiate different radial regions of the target plane 102. Moreover, as the height of the light-transmitting holes 312 increases, the irradiation radius of the heating lamps 40 also changes accordingly. The provision of the light-transmitting holes 312 can expand the irradiation range of the heating lamps 40 on the target plane 102, preventing the heating lamps 40 from being locally concentrated and irradiating the same radius, thereby reducing local temperature differences and achieving a gradual change in illumination intensity. Each view in FIG. 9 schematically shows two heating lamps 40

positioned symmetrically to the susceptor emitting light rays to the target plane 102 through their respective corresponding light-transmitting holes 312.

[0076] As an example, in each reflective assembly 30, the distances of adjacent light-transmitting holes 312 from the susceptor 130 are different. Thus, two adjacent heating lamps 40 can irradiate different radial ranges, achieving a gradual change in illumination intensity and improving the uniformity of heating.

[0077] An embodiment of the present disclosure also provides a semiconductor processing apparatus. Referring to FIG. 6, the semiconductor processing apparatus comprises a semiconductor chamber 100 and a heating device provided outside the semiconductor chamber 100. For example, an upper heating device 200 may be provided above the semiconductor chamber 100 and/or a lower heating device 300 may be provided below the semiconductor chamber 100. Both the upper heating device 200 and the lower heating device 300 may adopt the heating device described in the above embodiments, and the heating device is used to heat the susceptor 130 in the semiconductor chamber 100 during the process. As one example, a top plate 110 and a bottom plate 120 of the semiconductor chamber 100 may be made of a transparent material, such as quartz. A susceptor 130 for carrying a substrate is provided in the semiconductor chamber 100, and during the process, the lower heating device 300 heats the susceptor 130 through the bottom plate 120, and the upper heating device 200 heats the substrate through the top plate 110. The semiconductor processing apparatus may be a CVD silicon epitaxy device.

[0078] For other working principles and processes of the semiconductor processing apparatus in this embodiment, please refer to the above-described description of the heating device of the embodiment of the present disclosure, and will not be repeatedly described here.

[0079] The heating device and the semiconductor processing apparatus provided in the present disclosure have been described in detail above, and the principle and

implementation mode of the present disclosure have been described herein by applying specific examples. It should be noted that in the present disclosure, the description of each embodiment has different emphasis, and for parts not described or described in detail in a certain embodiment, please refer to the related description of other embodiments.

[0080] The above is only a preferred embodiment of the present disclosure and does not limit the disclosure scope of the present application. The characteristics of the technical solutions of the present disclosure can be combined arbitrarily. In order to make the description concise, all possible combinations of the technical features in the above embodiments are not described. Any equivalent structure or equivalent flow transformation made by using the contents of the specification and drawings of the present disclosure, or directly or indirectly applied to other related technical fields, as long as there is no contradiction in the combination of these technical features, is comprised in the patent protection scope of the present disclosure.

What is Claimed is:

1. A heating device for heating a susceptor in a semiconductor chamber, comprising:

a central region and multiple annular regions sequentially surrounding the central region outward from the central region, all of which are coaxial with a central axis of the susceptor;

wherein the heating device is disposed on one side of the susceptor in a perpendicular direction;

multiple heating lamps evenly distributed along a circumferential direction in each of the annular regions;

an annular reflective plate disposed on a side of the multiple heating lamps away from the susceptor in each of the annular regions; and

a reflective assembly disposed on one of the annular regions at a side adjacent to the central region in each of the annular regions, wherein the reflective assembly comprises multiple reflective plates in one-to-one correspondence with the heating lamps in said annular region;

wherein the reflective plates extend from the annular reflective plate toward the susceptor so as to guide a light emitted from the corresponding heating lamp to irradiate within a preset area of the susceptor;

wherein the reflective assembly enables the multiple heating lamps to respectively irradiate preset areas of the susceptor in different radial ranges; and wherein a central axis of the annular region is coaxial with a central axis of the susceptor.

2. The heating device of claim 1, wherein each of the reflective plates in the

reflective assembly is parallel to the central axis of the susceptor; or,

wherein an included angle between each of the reflective plates and the central axis of the susceptor is the same.

3. The heating device according to claim 2, wherein the heating lamps loaded in the same annular region are disposed at the same height;

wherein a distance between one end of the reflective plate adjacent to the susceptor and the susceptor is a first height of the reflective plate, and the first heights of the reflective plates in the same reflective assembly are different.

4. The heating device according to claim 3, wherein the first heights of any two adjacent reflective plates in the same reflective assembly are different.

5. The heating device according to claim 3, further comprising an actuator configured to adjust lifting of each of the reflective plates.

6. The heating device according to claim 2, wherein the heating lamps in the same annular region are of a same height;

wherein a distance between one end of the reflective plate adjacent to the susceptor and the susceptor is a first height of the reflective plate, and the first heights of the reflective plates in the same reflective assembly are a same; and

wherein in each reflective assembly, at least a part of the reflective plates are provided with light-transmitting holes, and a distance between each of the light-

transmitting holes and the susceptor is less than a distance between the corresponding heating lamp and the susceptor.

7. The heating device of claim 6, wherein in each reflective assembly, distances from two adjacent light-transmitting holes to the susceptor are different.

8. The heating device according to any one of claims 1 to 7, wherein in two adjacent annular regions, along a same radial direction, a distance between the heating lamp in an outer annular region and the susceptor is less than a distance between the heating lamp in an inner annular region and the susceptor.

9. The heating device according to any one of claims 1 to 7, wherein in the two adjacent annular regions, along the same radial direction, a first height of the reflective plate in an outer annular region is less than the first height of the reflective plate in an inner annular region.

10. The heating device according to any one of claims 1 to 7, wherein in each of the annular regions, the reflective assembly is symmetrical with respect to a center of the annular region.

11. The heating device according to any one of claims 1 to 7, further comprising a circular reflective plate disposed in the central region, wherein the reflective assembly in an innermost annular region is arranged around the circular reflective plate; and

a distance of the circular reflective plate from the susceptor is greater than a first

height of any of the reflective plates in the reflective assembly disposed in the innermost annular region.

12. A semiconductor processing apparatus comprising a semiconductor chamber, further comprising a heating device according to any one of claims 1 to 11 disposed above and/or below the semiconductor chamber, wherein the heating device is configured to heat a susceptor within the semiconductor chamber during processing.