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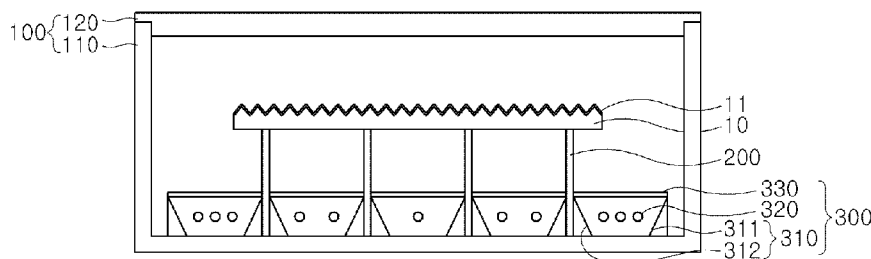
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(54) Title: SUBSTRATE HEATING APPARATUS

[Fig. 2]



(57) Abstract: A substrate heating apparatus is provided. The substrate heating apparatus includes a chamber, a substrate supporting unit configured to support at least one substrate where a thin film is formed on the top surface thereof, and at least one heating unit disposed in a region adjacent to the rear surface of the substrate. The heating unit includes a plurality of reflecting units arranged under the substrate, at least one lamp heating unit disposed inside the plurality of reflecting units, and a short-wavelength blocking layer disposed on the lamp heating unit. By providing the lamp heating unit under the substrate where the thin film or pattern is formed on the top surface, and supplying heat energy to the rear surface of the substrate, it is possible to prevent the degradation in efficiency of the thin film, such as degradation of the thin film formed on the top surface of the substrate due to the heat source or the peeling of the thin film due to the temperature deviation between the substrate and the thin film. Furthermore, the heat energy is widely spread out at the central region of the rear surface of the substrate, and the heat energy is focused at the edge region of the substrate, thereby heating the large-sized substrate uniformly.

Description

SUBSTRATE HEATING APPARATUS

Technical Field

- [1] The present invention relates to a substrate heating apparatus, and more particularly, to a substrate heating apparatus for pre-heating a large-sized substrate which is surface-processed or on which a thin film is deposited.

Background Art

- [2] Generally, since a large-sized substrate has a slow temperature-increase speed, it is heated up to a process temperature in a pre-heating chamber, i.e., a substrate heating apparatus, prior to a main process. That is, in the case where an unheated substrate is loaded into a chamber for a main process, an additional process time for heating the substrate is required. In addition, if a low-temperature substrate is loaded into a high-temperature main chamber, the substrate may be thermally damaged and the internal temperature of the main chamber is lowered.
- [3] Therefore, according to the related art, a substrate heating apparatus illustrated in FIG. 1 is provided for pre-heating the substrate.
- [4] Referring to FIG. 1, the conventional substrate heating apparatus includes a vacuum chamber 1, a substrate supporter 3 disposed at a lower portion of the vacuum chamber 1 to support a substrate 2, and a lamp heater 4 disposed at an upper portion of the vacuum chamber 1 to heat the substrate 2 placed on the substrate supporter 3. The conventional substrate heating apparatus performs the pre-heating process by placing the loaded substrate 2 on the substrate supporter 3 and heating the substrate 2 using the lamp heater 4 disposed over the substrate 2.
- [5] In the conventional substrate heating apparatus, however, in the case of forming a thin film on the substrate 2, the thin film is heated earlier than the substrate 2, thus causing a problem that the substrate 2 is not heated properly.
- [6] In recent years, a solar cell is fabricated using a thick special glass substrate where a predetermined pattern is formed on a glass substrate and a thin film is formed on the glass substrate including the predetermined pattern. When the thick special glass substrate is heated using the above-described conventional substrate heating apparatus, radiant heat from the lamp heater 4 arrives at the thin film with excellent light absorption rate earlier than the glass substrate. Thus, most radiant heat is absorbed on the surface of the thin film, so that the heating of the glass substrate is not performed properly. Thus, the temperature of the thin film receiving much radiant heat becomes high and that of the glass substrate becomes relatively low, causing great thermal stress between the substrate and the thin film due to a temperature deviation therebetween.

Such a thermal stress causes a problem that degrades the efficiency of a solar cell fabricated through subsequent processes. Furthermore, when a large-sized substrate is heated, the substrate may be distorted or broken by a temperature difference between the central region and the edge region of the substrate.

Disclosure of Invention

Technical Problem

- [7] The present invention provides a substrate heating apparatus in which a lamp heater is disposed under a substrate so that heat from the lamp heater is uniformly transmitted to the bottom of the substrate, thereby heating (increasing the temperature of) a large-sized substrate uniformly and reducing a temperature deviation between the substrate and a film formed thereon.

Technical Solution

- [8] In accordance with one aspect of the present invention, a substrate heating apparatus includes a chamber, a substrate supporting unit configured to support at least one substrate having a thin film formed over the top surface thereof, and at least one heating unit disposed in a region adjacent to the rear surface of the substrate, wherein the heating unit includes a plurality of reflecting units arranged under the substrate, at least one lamp heating unit disposed inside the plurality of reflecting units, and a short-wavelength blocking layer disposed on the lamp heating unit.
- [9] The short-wavelength blocking layer may be manufactured by coating a light blocking film having haze on a transparent substrate, or manufactured by coating a film having a light blocking characteristic on the transparent substrate by employing a print screen method, or manufactured by depositing a thin film having haze on the transparent substrate by employing a vacuum deposition method.
- [10] The short-wavelength blocking layer may block light of approximately 350 nm or less in a range of approximately 40% to approximately 80%.
- [11] Each of the reflecting unit may include mirrors arranged in a V-shape.
- [12] The mirrors of the reflecting units may have different slopes.
- [13] The plurality of reflecting units may be arranged in a direction parallel to the rear surface of the substrate, and the slopes of the mirrors inside the reflecting units disposed under the substrate gradually increase as going from a central region to an edge region of the rear surface of the substrate.
- [14] The plurality of reflecting units may be arranged in a direction parallel to the rear surface of the substrate, and the number of the lamp heating units inside the reflecting units disposed under the substrate gradually increases as going from a central region to an edge region of the rear surface of the substrate.
- [15] The short-wavelength blocking layer may have a plate shape to cover the plurality of

reflecting units where the lamp heating units are provided.

[16] The substrate heating apparatus may further include a gas supplying unit configured to supply inert gas flowing within the chamber.

[17] The chamber may use an in-line vertical chamber and include a plurality of substrates arranged vertically within the chamber, and a plurality of heating units disposed under the rear surfaces of the plurality of substrates.

Advantageous Effects

[18] As described above, by providing the lamp heating unit under the substrate where the thin film or pattern is formed on the top surface thereof, and supplying heat energy to the rear surface of the substrate, it is possible to prevent the degradation in efficiency of the thin film, such as degradation of the thin film formed over the top surface of the substrate due to the heat source and the peeling of the thin film due to the temperature deviation between the substrate and the thin film.

[19] Furthermore, the heat energy is widely spread out at the central region of the rear surface of the substrate, and the heat energy is focused at the edge region of the substrate, thereby heating, i.e., increasing the temperature of, the large-sized substrate uniformly.

Brief Description of the Drawings

[20] FIG. 1 is a cross-sectional view of a conventional substrate heating apparatus;

[21] FIG. 2 is a cross-sectional view of a substrate heating apparatus in accordance with an embodiment of the present invention; and

[22] FIGs. 3 to 5 are cross-sectional views of modifications of the substrate heating apparatus in accordance with the embodiment of the present invention.

Best Mode for Carrying Out the Invention

[23] FIG. 2 is a cross-sectional view of a substrate heating apparatus in accordance with an embodiment of the present invention.

[24] FIGs. 3 to 5 are cross-sectional views of modifications of the substrate heating apparatus in accordance with the embodiment of the present invention.

[25] Referring to FIG. 2, the substrate heating apparatus in accordance with the embodiment of the present invention includes a chamber 100, a substrate supporting unit 200 supporting a substrate 10, and a heating unit 300 disposed under the substrate 10. The heating unit 300 includes a plurality of reflecting units 310, a plurality of lamp heating unit 320 each disposed inside the plurality of reflecting units 310, and a short-wavelength blocking layer 330 disposed over the lamp heating unit 320.

[26] The chamber 100 includes a hollow chamber body 110, and a chamber lid 120 covering the chamber body 110. The chamber body 110 is formed in a pillar shape with an opened upper side and an empty inside. That is, the chamber body 110 has a

bottom surface, and sidewalls protruding from edges of the bottom surface. The bottom surface of the chamber body 110 may have a variety of shapes, for example, a polygonal shape, a circular shape or an oval shape, depending on the shape of the chamber 100. A reaction space is defined by the sidewalls and the bottom surface of the chamber body 110. The chamber lid 120 is connected to the chamber body 110 to seal the reaction space. The chamber lid 120 functions as a top wall of the chamber 100. Also, the chamber lid 120 is coupled with the chamber body 110 so that it can be opened and closed.

- [27] Although not shown, an opening/closing port through which the substrate is loaded and unloaded is provided at one side of the chamber 100. Also, although not shown, the heating chamber 100 in accordance with this embodiment may be connected through the opening/closing port to one side of a processing chamber, or a transfer chamber which transfers the substrate. Through the above installation, a low-temperature substrate can be pre-heated before it is loaded into the processing chamber.
- [28] The substrate supporting unit 200 includes a plurality of substrate supporting pins which support the substrate 10. The plurality of substrate supporting pins support the rear surface of the substrate 10.
- [29] The substrate 10 used in this embodiment is a large-sized special substrate. That is, a substrate of FIG. 1 which has a convex-concave pattern formed thereon is used as the special substrate and layer(s) may be further formed on the convex-concave pattern. As the special substrate, a transparent substrate formed of, for example, glass or resin, is used. In this embodiment, a glass substrate for fabrication of a solar cell is used as the substrate 10. In this case, a mountain-shaped convex-concave pattern may be formed on the top surface of the glass substrate, and a transparent electrode may be formed over the glass substrate where the convex-concave pattern is formed.
- [30] Since the convex-concave pattern or a desired layer is formed on the top surface of the substrate 10, the rear surface, i.e., the bottom surface, of the substrate, where the convex-concave pattern or the desired layer is not formed, may be supported by the substrate supporting pins.
- [31] In this embodiment, the substrate supporting unit 200 using the plurality of substrate supporting pins can achieve the point contact between the substrate 10 and the substrate supporting unit 200. In this way, when heating the substrate 10, heat variation due to the substrate supporting unit 200 can be minimized, and it is possible to minimize the blocking of the radiant heat of the lamp heating unit 320 inside the heating unit 300 due to the substrate supporting unit 200.
- [32] The substrate supporting pins of the substrate supporting unit 200 may go up and down. Thus, the plurality of substrate supporting pins go down when the substrate 10 is

loaded into the heating chamber 100, and then go up to support the substrate 10 when the loading of the substrate 10 is completed. After the heating of the substrate 10 is completed, the plurality of substrate supporting pins go down again to facilitate the unloading of the substrate 10. To this end, the substrate supporting unit 200 includes a separate actuator for moving the plurality of substrate supporting pins upward and downward.

[33] The heating unit 300 is installed under the substrate 10 to heat all sides of the substrate 10 uniformly. As described above, the heating unit 300 includes the plurality of reflecting units 310, the plurality of lamp heating units 320, and the short-wavelength blocking layer 330.

[34] The heating unit 300 includes the plurality of reflecting units 310 reflecting light radiated from the lamp heating unit 320 toward the rear surface of the substrate 10. In FIG. 2, five reflecting units 310 are provided. That is, one reflecting unit 310 is provided at a central region of the rear surface of the substrate 10; two reflecting units 310 are provided at an edge region of the rear surface of the substrate 10; and two reflecting units 310 are provided between the reflecting unit 310 provided at the central region and the reflecting units 310 provided at the edge region. It is apparent that the present invention is not limited to this embodiment, and the heating unit 300 may include less or more reflecting units 310. For example, like the modifications of FIGs. 3 and 5, seven numbers of reflecting units 310 may be provided. The number of the reflecting units 310 may be varied depending on the size of the substrate 10 to be heated and the heating capability of the lamp heating unit 320.

[35] The substrate supporting unit 200 supporting the rear surface of the substrate 10 is provided between the plurality of reflecting units 310 provided under the rear surface of the substrate 10.

[36] Each of the plurality of reflecting units 310 includes mirrors 311 and 312 arranged in a V-shape. In this case, as illustrated in FIG. 2, each of the plurality of reflecting units 310 includes a first mirror 311 inclined from a right upper end toward a left lower end, and a second mirror 312 inclined from a left upper end to a right lower end. It is apparent that the present invention is not limited to this embodiment, and the reflecting unit 310 may be a mirror that is integrally formed in a V-shape.

[37] The slopes of the first mirror 311 and the second mirror 312 inside the reflecting unit 310 may be identical to each other. It is apparent that the present invention is not limited to this embodiment, and the slopes, if necessary, may be different from each other. As illustrated in FIG. 2, it is preferable that the slopes of the mirrors inside each reflecting unit 310 are identical to each other.

[38] The present invention is not limited to this embodiment, and the slopes of the mirrors inside the reflecting units 310 may be different from each other, as illustrated in the

modifications of FIGs. 3 and 5. That is, the slopes of the mirrors inside the reflecting units 310 may increase from the central region toward the edge region of the rear surface of the substrate 10. The slope represents the angle between the mirrors 311 and 312 and the bottom surface of the chamber 100. As illustrated in FIGs. 3 and 5, the mirrors 311 and 312 inside the reflecting unit 310 disposed under the central region of the rear surface of the substrate 10 may have the smallest slope, and the mirrors 311 and 312 inside the reflecting unit 310 disposed under the edge region of the rear surface of the substrate 10 may have the largest slope.

[39] The lamp heating unit 320 is disposed inside the reflecting unit 310 of this exemplary embodiment. Accordingly, due to the slope difference of the mirrors disposed inside the reflecting units 310 in the above-described modification, light reflected by the reflecting unit 310 disposed under the central region of the rear surface of the substrate 10 is widely spread out, and light reflected by the reflecting unit 310 disposed under the edge region of the rear surface of the substrate 10 is focused, thereby heating the central region and the edge region of the substrate 10 uniformly. Compared with the central region of the substrate 10, the edge region of the substrate 10 is adjacent to elements having temperature lower than the heating temperature of the substrate 10 just like the sidewalls of the chamber 100. Therefore, when uniform heat energy is applied to the central region and the edge region of the substrate 10, the heat energy is absorbed by low-temperature elements, i.e., chamber, as it goes toward the edge region of the substrate 10. In this exemplary embodiment, the heat energy reflected by the reflecting unit 310 is widely spread out at the central region and is gradually focused as it goes toward the edge region to compensate the heat energy absorbed by surroundings at the edge region of the substrate 10. In this way, heat energy can be uniformly applied to the substrate 10.

[40] The plurality of reflecting units 310 are arranged on the bottom surface of the chamber 100 in parallel to the rear surface of the substrate 10. Assuming that a distance between the first mirror disposed at the right upper end of the reflecting unit 310 and the second mirror disposed at the left upper end is defined as a width of the reflecting unit 310, the widths of the reflecting units 310 may be identical to each other, as illustrated in FIG. 2. The present invention is not limited to this embodiment, and the widths of the reflecting units 310 may gradually decrease from the central region toward the edge region, as illustrated in FIGs. 3 and 5. Through this configuration, as described above, the heat energy can be widely spread out at the central region, and the heat energy can be focused at the edge region.

[41] At least one lamp heating unit 320 is provided in each of the reflecting units 310. The number of the lamp heating units 320 provided inside the reflecting unit 310 may gradually increase from the central region toward the edge region of the rear surface of

the substrate 10. That is, as illustrated in FIG. 2, one lamp heating unit 320 is provided inside the reflecting unit 310 disposed under the central region; three lamp heating units 320 are provided inside the reflecting unit 310 disposed under the edge region; and two lamp heating units 320 are provided inside the reflecting unit 310 disposed between the reflecting unit 310 disposed under the central region and the reflecting unit 310 disposed under the edge region. In this embodiment, such a configuration can gradually increase an amount of heat energy as going from the central region to the edge region of the rear surface of the substrate 10. As described above, such a configuration can provide heat energy to the central region and the edge region of the large-sized substrate 10 uniformly. It is apparent that the present invention is not limited to this exemplary embodiment, and one lamp heating unit 320 may be provided inside one reflecting unit 310 as illustrated in the modification of FIG. 5.

[42] The lamp heating unit 320 represents an optical heating unit and uses a lamp heater. The lamp heating units 320 provided inside the plurality of reflecting units 310 are simultaneously driven to provide radiant heat to the rear surface of the substrate 10. It is apparent that the present invention is not limited to this exemplary embodiment, and the plurality of lamp heating units 320 inside the reflecting units 310 may be individually driven.

[43] The heating unit 300 includes the short-wavelength blocking layer 330 over the plurality of lamp heating units 320. As illustrated in FIG. 2, the short-wavelength blocking layer 330 is formed in a plate shape to cover the plurality of reflecting units 310 where at least one lamp heating unit 320 is provided. The short-wavelength blocking layer 330 controls the wavelength of the output light of the lamp heating unit 320 to thereby uniformly heat the substrate 10 and the layer 11 formed over the substrate 10. In this exemplary embodiment, the lamp heating unit 320 is disposed under the rear surface of the substrate 10 so that the heat energy is first applied to the rear surface of the substrate 10 to thereby prevent the heat energy from being absorbed by the layer 11 formed over the substrate 10. In this way, the large-sized thick substrate 10 can be heated in a short time.

[44] The short-wavelength blocking layer 330 blocks a portion of short-wavelength light having a wavelength of, e.g., 350 nm or less, through light absorption, diffraction and reflection.

[45] The short-wavelength blocking layer 330 is manufacture by coating a light blocking film on a transparent substrate. In this case, the light blocking film uses a film that has haze and can be tolerated at high temperature. In accordance with another embodiment, the short-wavelength blocking layer 330 may be manufactured by coating a layer having light blocking characteristic on a transparent substrate by using a print screen method. That is, liquid material having haze is coated on the substrate using the print

screen method and then thermally treated to manufacture the short-wavelength blocking layer 330. Furthermore, the present invention is not limited to those embodiments, and the short-wavelength blocking layer 330 may be manufactured by forming a thin film having haze on the transparent substrate by using a vacuum deposition method. As the vacuum deposition method, chemical vapor deposition (CVD) or metal-organic chemical vapor deposition (MOCVD) may be used, and it is effective to use a precursor having a light absorption characteristic during the MOCVD process. In this case, various layers as well as a silicon layer can be used as the thin film having haze.

- [46] The light transmittance of the short-wavelength blocking layer 330 can be varied depending on an amount of the haze.
- [47] The lamp heating unit 320 emits light having a short wavelength to a long wavelength. The light having the short wavelength has high heat energy and excellent diffraction and reflection characteristics. On the other hand, the light having the long wavelength has lower heat energy than the short wavelength, but has excellent transmittance. Therefore, when the lamp heating unit 320 is disposed under the rear surface of the substrate 10, the lower region of the substrate 10 is first heated by the light of the short wavelength having high energy, and the upper region of the substrate 10 is heated later by the light of the long wavelength having low energy. That is, the short-wavelength light heats the light contact surface where the short-wavelength light having the high energy reaches, but its short wavelength makes it relatively difficult to increase temperature uniformly up to the opposite side where the light does not reach. Compared with the short-wavelength light, the long-wavelength light does not supply high energy to the light contact surface, but it penetrates deeply because of the long wavelength, so that the temperature of the opposite side where the light does not reach is increased uniform.
- [48] As described above, in this exemplary embodiment, the short-wavelength blocking layer 330 is provided in a space between the lamp heating unit 320 and the substrate 10 so as to block a portion of the short wavelength of the light emitted from the lamp heating unit 320. Therefore, the rear surface and the top surface of the substrate 10, and the layer 11 formed over the substrate 10 can be heated uniformly. That is, by blocking the portion of the short wavelength of the light supplied to the lower region of the substrate 10 in a thickness direction of the substrate 10, an amount of light energy applied to the lower region of the substrate 10 and an amount of light energy applied to the upper region of the substrate 10 are made uniform. The short-wavelength blocking layer 330 may block about 40-80% of the short wavelength, for example, 350 nm or less, of the applied light. As described above, the wavelength blocking degree may be adjusted by controlling an amount of haze of the short-wavelength blocking layer 330.

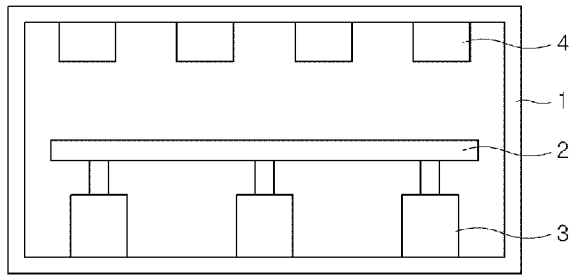
- [49] For example, in the case where the short-wavelength blocking layer 330 blocks about 50% of the short wavelength of the light supplied from the lamp heating unit 320, the short-wavelength light having 50% of the original energy is supplied to the lower region of the substrate 10, and the long-wavelength light having unchanged energy is supplied to the upper region of the substrate 10. In this way, the short-wavelength light of high energy supplied to the lower region of the substrate 10 is reduced to have an energy level similar to that of the long-wavelength light of low energy, thus achieving uniform-heating in a thickness direction of the substrate 10.
- [50] The short-wavelength blocking layer 330 blocks the short-wavelength light applied from the lamp heating unit 320 and also is heated by the short-wavelength light. Thus, the substrate 10 can be also heated by the heated short-wavelength blocking layer 330.
- [51] As described in FIG. 4, the upper and lower regions of the substrate can be uniformly heated by using a convection phenomenon of inert gas supplied into the chamber 10. That is, the inert gas supplied into the chamber 10 is heated at the lower region of the substrate and the heated inert gas moves to the upper region of the substrate to heat the upper region. For this, the embodiment illustrated in FIG. 4 further includes a gas supplying unit 400 that supplies the inert gas into the chamber 10.
- [52] In addition, as illustrated in FIG. 5, two substrates 10 may be simultaneously heated using two heating units 300 in an in-line vertical chamber 100. That is, the two substrates 10 are arranged so that their rear surfaces are faced to each other, and the two heating units 300 are arranged in a space between the rear surfaces of the two substrates 10. In such a state, the substrates 10 can be individually heated by the heating units 300. In this case, the heating of the substrates 10 may use radiation energy or convection energy of inert gas.
- [53] Although a substrate heating apparatus of the present invention has been described with reference to the specific embodiments, they are not limited thereto. Therefore, it will be readily understood by those skilled in the art that various modifications and changes can be made thereto without departing from the spirit and scope of the present invention defined by the appended claims.

Claims

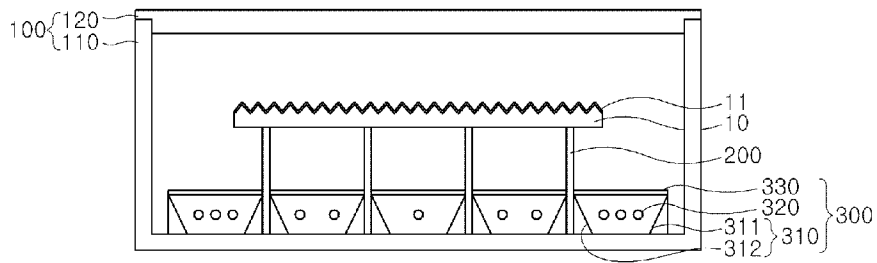
- [1] A substrate heating apparatus, comprising:
a chamber;
a substrate supporting unit configured to support at least one substrate having a thin film formed over the top surface thereof; and
at least one heating unit disposed in a region adjacent to the rear surface of the substrate,
wherein the heating unit comprises:
a plurality of reflecting units arranged under the substrate;
at least one lamp heating unit disposed inside the plurality of reflecting units; and
a short-wavelength blocking layer disposed on the lamp heating unit.
- [2] The substrate heating apparatus of claim 1, wherein the short-wavelength blocking layer is manufactured by coating a light blocking film having haze on a transparent substrate, or manufactured by coating a film having a light blocking characteristic on the transparent substrate by employing a print screen method, or manufactured by depositing a thin film having haze on the transparent substrate by employing a vacuum deposition method.
- [3] The substrate heating apparatus of claim 1, wherein the short-wavelength blocking layer blocks light of approximately 350 nm or less in a range of approximately 40% to approximately 80%.
- [4] The substrate heating apparatus of claim 1, wherein each of the reflecting unit comprises mirrors arranged in a V-shape.
- [5] The substrate heating apparatus of claim 4, wherein the mirrors of the reflecting units have different slopes.
- [6] The substrate heating apparatus of claim 4, wherein the plurality of reflecting units are arranged in a direction parallel to the rear surface of the substrate, and the slopes of the mirrors inside the reflecting units disposed under the substrate gradually increase as going from a central region to an edge region of the rear surface of the substrate.
- [7] The substrate heating apparatus of claim 1, wherein the plurality of reflecting units are arranged in a direction parallel to the rear surface of the substrate, and the number of the lamp heating units inside the reflecting units disposed under the substrate gradually increases as going from a central region to an edge region of the rear surface of the substrate.
- [8] The substrate heating apparatus of claim 1, wherein the short-wavelength blocking layer has a plate shape to cover the plurality of reflecting units where the lamp heating units are provided.

- [9] The substrate heating apparatus of claim 1, further comprising a gas supplying unit configured to supply inert gas flowing within the chamber.
- [10] The substrate heating apparatus of claim 1, wherein the chamber uses an in-line vertical chamber, and includes a plurality of substrates arranged vertically within the chamber and a plurality of heating units disposed under the rear surfaces of the plurality of substrates.

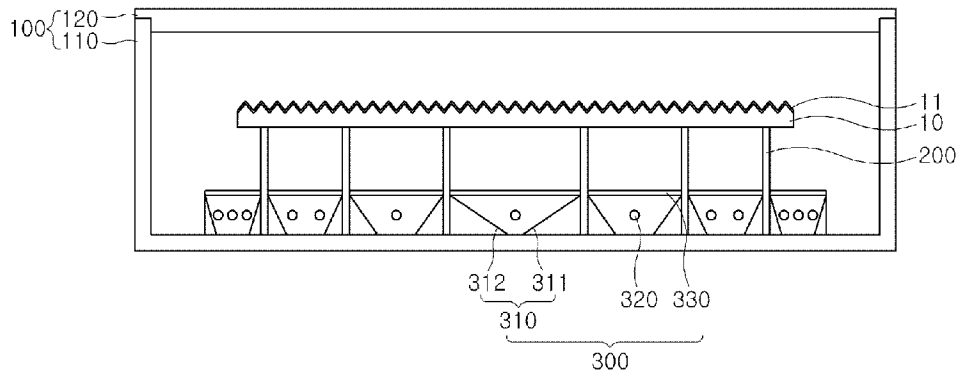
[Fig. 1]



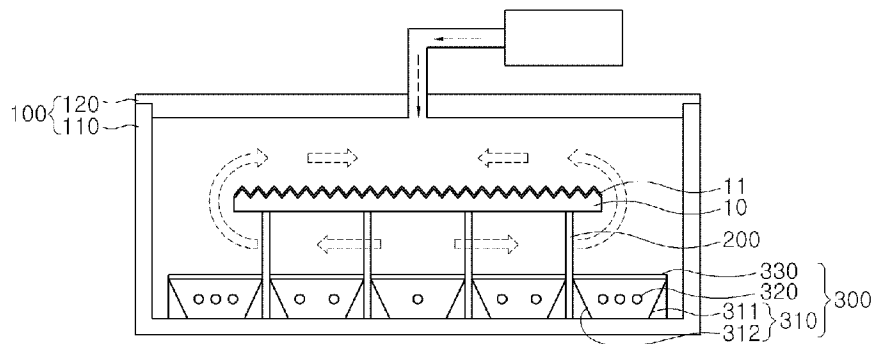
[Fig. 2]



[Fig. 3]



[Fig. 4]



[Fig. 5]

