

【SPECIFICATION】

【TITLE OF THE DISCLOSURE】

SEMICONDUCTOR MANUFACTURING APPARATUS FOR EPITAXIAL PROCESS

【TECHNICAL FIELD】

The present disclosure relates to a semiconductor manufacturing apparatus for an epitaxial process, which deposits a thin film on a flat substrate including a semiconductor substrate, using an epitaxial process.

【BACKGROUND ART】

A semiconductor substrate or a flat substrate such as a glass substrate for a flat panel display device may be manufactured into a semiconductor or flat panel display module by performing a heat treatment process such as an epitaxial process, a thin film crystallization process, an ion implantation process, or an activation process.

The epitaxial process is a process for growing a required thin film on a surface of a semiconductor substrate, and may be carried out in a semiconductor manufacturing apparatus having a process chamber. The epitaxial process may be carried out by heating the semiconductor heating region a predetermined temperature or more while injecting a process gas into the process chamber maintained under vacuum. It is necessary to keep the temperature of the semiconductor substrate uniformly throughout during the epitaxial process. In addition, it is necessary for the process chamber to be durable and heat-resistant, as the interior thereof is kept at a high temperature. Furthermore, it is necessary for the process chamber to be sealed so that process gas does not leak to the outside. On the other hand, in a semiconductor manufacturing apparatus in which the above epitaxial process is carried out, attempts have recently been being made to use a VCSEL (Vertical Cavity Surface Emitting Laser) device that irradiates a laser beam to a semiconductor heating region heat it. A substrate heating unit formed by arranging a plurality of VCSEL devices is capable of

irradiating a laser beam to a lower surface of the semiconductor heating region heat it. Due to the miniaturization of semiconductor technology, the semiconductor substrate requires a small temperature deviation and a high temperature uniformity during the heating process. Since the semiconductor substrate is supported by a separate substrate support at an outer lower surface thereof, a relatively large amount of heat can be dissipated to a region which is in contact with the substrate support. Therefore, the semiconductor substrate may not be used for forming a device because the temperature of an inner part of the semiconductor substrate is lower than that of an outer part.

【DISCLOSURE】

【TECHNICAL PROBLEM】

An object of the present disclosure is to provide a semiconductor manufacturing apparatus for an epitaxial process capable of uniformly heating an entire semiconductor substrate.

【TECHNICAL SOLUTION】

A semiconductor manufacturing apparatus for an epitaxial process according to the present disclosure includes a process chamber having an edge ring configured to support an outer lower surface of a semiconductor substrate such that a lower surface of the semiconductor substrate is exposed, a substrate support configured to support an outer lower surface of the edge ring, and a laser beam transmitting plate positioned below the semiconductor substrate; a substrate heating unit configured to irradiate a laser beam of a VCSEL module to lower surfaces of the semiconductor substrate and the edge ring through the laser beam transmitting plate; and a beam guiding part configured to irradiate the laser beam of the VCSEL module to the lower surface of the edge ring, wherein the substrate heating unit is divided into a substrate heating region on which the VCSEL module is placed, an edge heating region, and a support heating region, and wherein the beam guiding part guides the laser beam irradiated from the VCSEL module positioned on the support heating

region to the lower surface of the edge ring.

In addition, the edge ring is extended in an outward direction from an upper portion of an inner circumference surface and has an inner diameter greater than an outer diameter of the semiconductor substrate, and the substrate support may include an upper support, and the upper support may have an edge ring supporting hole having an inner diameter smaller than an outer diameter of the edge ring and an edge ring-supporting stepped-jaw extended in an outward direction from an upper portion of an inner circumference surface of the edge ring supporting hole and having an inner diameter greater than an outer diameter of the edge ring.

Also, the edge ring may have an emissivity per unit area, with respect to a horizontal plane, which is equal to or greater than that of the semiconductor substrate.

Furthermore, the laser beam transmitting plate may have a transmissive substrate region, a transmissive edge region and a transmissive support region corresponding to the substrate heating region, the edge heating region and the support heating region, respectively, and a lower surface of the beam guiding part may be positioned on the transmissive support region and an upper surface may be positioned below the edge ring.

Also, the beam guiding part may be formed such that the lower and upper surfaces are horizontal surfaces, a central axis is a straight line, and the central axis makes an angle, which is smaller than 90 degrees, with the lower surface.

In addition, the beam guiding part may be formed such that a central axis makes a vertical straight line at its lower portion and an inclined straight line at its upper portion, and the inclined straight line and the vertical straight line may make an angle greater than 90 degrees with each other.

Furthermore, the beam guiding part may be formed such that a central axis makes a lower vertical straight line, an intermediate inclined straight line and an upper vertical straight line.

Also, the beam guiding part may be formed from quartz material.

【ADVANTAGEOUS EFFECT】

In the semiconductor manufacturing apparatus for the epitaxial process according to the present disclosure, the substrate heating unit consisting of the VCSEL devices may heat the edge ring simultaneously to heat uniformly the semiconductor substrate.

Furthermore, in the semiconductor manufacturing apparatus for the epitaxial process according to the present disclosure, by separately irradiating the laser beam to the edge ring supporting the outer part of the semiconductor heating region heat the edge ring to a temperature similar to that of the semiconductor substrate, a heat dissipation from the semiconductor substrate through the edge ring is reduced, and the temperature of the semiconductor substrate can also be made uniform.

In addition, the semiconductor manufacturing apparatus for the epitaxial process of the present disclosure may heat the edge ring, that supports the outer part of the semiconductor substrate, using the laser beam irradiated from the substrate heating unit, so separate heating means may not be required.

Also, the semiconductor manufacturing apparatus for the epitaxial process of the present disclosure may heat the outer and inner parts of the semiconductor substrate uniformly throughout, thereby increasing the semiconductor substrate region on which devices are formed.

【DESCRIPTION OF DRAWINGS】

FIG. 1 is a view showing a schematic configuration of a semiconductor manufacturing apparatus for an epitaxial process according to one embodiment of the present disclosure.

FIG. 2 is a partial enlarged view of “A” section of FIG. 1.

FIG. 3 is a horizontal cross-sectional view taken along the line B-B of FIG. 1.

FIG. 4 is a partial perspective view of a substrate heating unit of FIG. 1.

FIG. 5 is a partial perspective view of a substrate heating part according to another embodiment of the present disclosure.

FIG. 6 is a partial perspective view of a substrate heating unit according to yet another embodiment of the present disclosure.

FIG. 7 is a vertical cross-sectional view of a beam guiding part according to another embodiment of the present disclosure.

FIG. 8 is a vertical cross-sectional view of a beam guide part according to yet another embodiment of the present disclosure.

FIG. 9 is a view showing a result of simulating a guidance direction and irradiation density of a laser beam of a beam guiding part of FIG. 1.

FIG. 10 is a view showing a result of simulating a guidance direction and irradiation density of a laser beam of a beam guiding part of FIG. 7.

FIG. 11 is a view showing a result of simulating a guidance direction and irradiation density of a laser beam of a beam guiding part of FIG. 8.

FIG. 12 is a view showing a result of simulating a guidance direction and irradiation density of a laser beam in the absence of a beam guiding part.

【BEST MODE OF THE DISCLOSURE】

Hereinafter, a semiconductor manufacturing apparatus for an epitaxial process of the present disclosure is described in more detail with reference to embodiments and the accompanying drawings.

First, a configuration of a semiconductor manufacturing apparatus for an epitaxial process according to one embodiment of the present disclosure is described.

FIG. 1 is a view showing a schematic configuration of a semiconductor manufacturing apparatus for an epitaxial process according to one embodiment of the present disclosure.

FIG. 2 is a partial enlarged view of “A” section of FIG. 1. FIG. 3 is a horizontal cross-sectional view taken along the line B-B of FIG. 1. FIG. 4 is a partial perspective view of a substrate heating unit of FIG. 1. FIG. 5 is a partial perspective view of a substrate heating unit according to another embodiment of the present disclosure. FIG. 6 is a partial perspective

view of a substrate heating unit according to yet another embodiment of the present disclosure. FIG. 7 is a vertical cross-sectional view of a beam guiding part according to another embodiment of the present disclosure. FIG. 8 is a vertical cross-sectional view of a beam guide unit according to yet another embodiment of the present disclosure.

Referring to FIGS. 1 to 4, a semiconductor manufacturing apparatus 10 for an epitaxial process according to one embodiment of the present disclosure may include a process chamber 100, a substrate heating unit 200, and a beam guiding part 300. Further, the semiconductor manufacturing apparatus 10 for an epitaxial process may include a cooling gas spraying unit 400 and a substrate rotating unit 500.

The semiconductor manufacturing apparatus 10 for the epitaxial process may deposit a thin film on a surface of a semiconductor substrate a using an epitaxial process. For example, the semiconductor manufacturing apparatus 10 may be used to form a multi-layered thin film of $[\text{Si}/\text{SiGex}]_n$ on the semiconductor substrate a by the epitaxial process.

Also, the semiconductor manufacturing apparatus 10 for the epitaxial process may be applied to a semiconductor manufacturing process such as a crystallization process, an ion implantation process, or an activation process. The semiconductor manufacturing apparatus 10 for the epitaxial process may be applied to the semiconductor substrate a such as a glass substrate in addition to the semiconductor substrate a such as a wafer. Furthermore, the semiconductor manufacturing apparatus 10 for the epitaxial process may also be applied to a flexible substrate such as a resin film. In addition, the semiconductor substrate a may include various elements or electrically-conductive patterns formed on the surface thereof or therein.

the semiconductor manufacturing apparatus 10 may irradiate a laser beam generated by the substrate heating unit 200 to the semiconductor substrate A to heat the semiconductor substrate a. In the semiconductor manufacturing apparatus 10 for the epitaxial process, the substrate heating unit 200 may include a plurality of VCSEL devices for heating the semiconductor substrate a. The VCSEL device may irradiate a laser beam with a single

wavelength. For example, the VCSEL device may preferably be a device that irradiates a laser beam with a single wavelength of approximately 940nm. Alternatively, the VCSEL device may be a device that irradiates a laser beam with multiple wavelengths.

The Semiconductor manufacturing apparatus 10 may directly support an outer lower surface of the semiconductor substrate a. Since the semiconductor manufacturing apparatus 10 directly supports the semiconductor substrate a, it is possible to rapidly heat or cool the semiconductor substrate a in the deposition temperature range of the epitaxial process of 400 to 1,000°C. Furthermore, since the semiconductor manufacturing apparatus 10 directly heats the semiconductor substrate a, changes in the deposition temperature and deposition rate may be reduced even in a bowing phenomenon of the semiconductor substrate a that occurs in the epitaxial process.

The process chamber 100 may include an outer housing 110, an inner housing 120, an edge ring 130, a substrate support 140, a laser beam transmitting plate 150, and an infrared-ray transmitting plate 160.

The process chamber 100 may have a chamber upper space 100a in which the semiconductor substrate a is received and heat treated, with chamber upper space being formed above the outer housing 110 within the process chamber. The chamber upper space 100a may be formed above the inner housing 120 within the outer housing 110, and may provide a space in which the semiconductor substrate a is placed and the epitaxial process is performed. Further, the process chamber 100 may have a chamber lower space 100b formed between the outer housing 110 and the inner housing 120. The chamber lower space may provide a space in which a portion of the substrate rotating unit 500 is housed.

The semiconductor substrate a may be supported such that its lower surface is exposed within the process chamber 100 by the substrate support 140 and the edge ring 130. The process chamber 100 is configured such that the laser beam generated by the substrate heating unit placed outside is irradiated to the lower surface of the flat substrate placed inside.

The process chamber 100 is configured such that the laser beam passes through the laser beam transmitting plate 150 to be irradiated to the lower surface of the semiconductor substrate a seated on the substrate support 140 and the edge ring 130.

The outer housing 110 may include an outer upper wall body 111 and an outer lower wall body 113, and an upper plate 115 and a lower plate 117. The outer housing 110 may be formed in the shape of a barrel which is hollow on the inside as a whole. The outer housing 110 may be formed in a roughly cylindrical shape, a square barrel shape, a pentagonal barrel shape, or a hexagonal barrel shape. The outer housing 110 may be formed in a shape having a horizontal cross-sectional area larger than an area of the semiconductor substrate a to be received therein. The outer upper wall body 111 and the outer lower wall body 113 may be integrally formed with each other.

The outer housing 110 may be formed from a metallic material that is resistant to breakage due to pressure and temperature changes, to cope with positive and negative pressure conditions and a rapid temperature change condition encountered during manufacturing. Further, the outer housing 110 may be formed from a metallic material that is corrosion-resistant to process gases used in the manufacturing process. The outer housing 110 may be formed from a metallic material such as stainless steel, an invar alloy, or hastelloy.

The outer upper wall body 111 may be formed in the shape of a barrel which is hollow on the inside. The outer upper wall body 111 may be formed in a cylindrical shape, a square barrel shape, a pentagonal barrel shape, or a hexagonal barrel shape. The outer upper wall body 111 may provide a space within which a portion of the substrate rotating unit 500, the substrate support 140, and the semiconductor substrate a are received.

The outer upper wall body 111 may include a process gas supply hole 111a and a process gas discharge hole 111b. Further, the outer upper wall body may be further provided with a cooling gas discharge hole 111c.

The process gas supply hole 111a may be formed in one side of the outer upper wall

body 111 and pass through the outer upper wall body 111 from the outside thereof to the chamber upper space 100a. The process gas supply hole 111a may be formed such that its inner end is parallel to an upper surface of the semiconductor substrate a at the same height. The process gas supply hole 111a may be formed in a straight shape, a curved shape, or a bent shape depending on a location, at which it is formed, in the outer upper wall body 111. The process gas supply hole 111a may provide a flow passage for supplying a process gas to the chamber upper space 100a.

The process gas discharge hole 111b may be formed in the other side of the outer upper wall body 111 and pass through the outer upper wall body from the chamber upper space 100a to the outside. The process gas discharge hole may be placed below the process gas supply hole 111a. The process gas discharge hole 111b may be formed in a straight shape, a curved shape, or a bent shape depending on a location, at which it is formed, in the outer upper wall body 111. The process gas discharge hole 111b may provide a flow passage from the chamber upper space 100a to the outside.

The process gas may flow through the process gas supply hole 111a, and may be then deposited as a thin film while flowing through a space between the upper surface of the semiconductor substrate a and the infrared-ray transmitting plate 160. Unreacted process gas in the process gas and a by-product generated after deposition may be discharged to the outside of the process chamber 100 via the process gas discharge hole 111b.

The cooling gas discharge hole 111c may be formed above the infrared-ray transmitting plate 160 and pass through the outer upper wall body 111 from an inner side thereof to an outer side. The cooling gas discharge hole 111c may provide a flow passage for discharging the cooling gas, which is sprayed above the infrared-ray transmitting plate 160, to the outside. In other words, the cooling gas discharge hole 111c may provide a flow passage through which the cooling gas which flows into a cooling gas spraying space 100c described below is discharged to the outside.

The outer lower wall body 113 may be formed in the shape of a barrel which is hollow on the inside. The outer upper wall body 110 may be formed in a cylindrical shape, a square barrel shape, a pentagonal barrel shape, or a hexagonal barrel shape. The outer lower wall body 113 may be formed in the shape which is the same as or similar to that of the outer upper wall body 111. The outer lower wall body 113 may be formed to have a diameter or width which is the same as or similar to that of the outer upper wall body 111. The outer lower wall body 113 may be coupled to a lower portion of the outer upper wall body 111. The outer lower wall body 113 may provide a space within which the inner housing 120 and a portion of the substrate rotating unit 500 are received.

The upper plate 115 may be formed in a plate shape corresponding to an upper plane shape of the outer upper wall body 111. The upper plate 115 may be coupled to an upper portion of the outer upper wall body 111 to shield an upper portion of the outer upper wall body 111. The upper plate 115 may be formed from a metallic material such as stainless steel, an invar alloy, or hastelloy.

The upper plate 115 may include an upper through-hole 115a. The upper through-hole 115a may be formed in an inner part of the upper plate 115 and pass through the upper plate from an upper surface to a lower surface thereof. The upper through-hole 115a may be formed to have a diameter or width which is necessary to fully expose the infrared-ray transmitting plate 160. The upper through-hole 115a may provide a space, by which an upper portion of the infrared-ray transmitting plate 160 is exposed and through which cooling gas sprayed from the cooling gas spraying unit 400 flows to an upper surface of the infrared-ray transmitting plate 160. Thus, the upper through-hole 115a may form an upper cooling gas flow passage 100e above the infrared-ray transmitting plate 160. The cooling gas may be nitrogen (N₂), argon (Ar), or dry air. The cooling gas may cool the infrared-ray transmitting plate 160.

The upper plate 115 may further include a ring-shaped upper support ring 116

extending downwardly from a lower surface of an inner part thereof. The upper support ring 116 may be formed to have with predetermined height and width. The upper support ring 116 may be coupled with the infrared-ray transmitting plate 160 such that a lower surface the upper supporting ring comes into contact with an upper surface of an outer part of the infrared-ray transmitting plate 160. The upper support ring 116 may increase a height of the upper cooling gas flow passage 100e to increases a gas residence time of the cooling gas in the upper cooling gas flow passage 100e. Thus, the cooling gas may effectively cool the infrared-ray transmitting plate 160, while reducing amount of use

The lower plate 117 may be formed in a plate shape corresponding a plane shape of a lower end of the outer lower wall body 113. The lower plate 117 may include a lower through-hole 117a passing through an inner part thereof from an upper surface to a lower surface. The lower plate 117 may be formed as a circular ring or a square ring having a predetermined width. The lower plate 117 may be coupled to a lower end of the outer lower wall body 113 and may shield an outer side of the outer lower wall body 113. The bottom plate 117 may seal a space between the outer lower wall body 113 and a lower portion of the inner housing 120. That is, the lower plate 117 may seal a lower portion of the chamber lower space 101b. The lower plate 117 may be formed from a metallic material such as stainless steel, an invar alloy, or hastelloy.

The inner housing 120 is formed in the shape of a barrel which is hollow on the inside, and may be formed in acylindrical shape, a square barrel shape, a pentagonal barrel shape, or a hexagonal barrel shape. The inner housing 120 may be formed to have an outer diameter or outer width that is smaller than an inner diameter or inner width of the outer lower wall body 113. Further, the inner housing 120 may be formed to have a height that is smaller than that of the outer lower wall body 113. In addition, the upper part of the inner housing (120) may be formed at a height at which a semiconductor substrate (a) is placed inside the process chamber (100). Furthermore, the inner housing 120 may be formed to have a diameter or

width greater than that of the semiconductor substrate a. In addition, the inner housing 120 may be formed to have a horizontal area larger than that of the semiconductor substrate a.

Further, the inner housing 120 may be coupled to the outer housing 110 such that its lower portion and a lower portion of the outer housing 110 are at roughly the same level. A lower end of the inner housing 120 may be coupled to an inner part of the lower plate 117. A space between an outer side of the inner housing 120 and an inner side of the outer housing 110 may be sealed by the lower plate 117. The inner housing 120 may be formed from a metallic material such as stainless steel, an invar alloy, or hastelloy.

The edge ring 130 may be formed to have a ring shape as a whole. The edge ring 130 may be formed to have an inner diameter smaller than an outer diameter of the semiconductor substrate a. The edge ring 130 may be formed such that its upper surface is at the same level as the upper surface of the semiconductor substrate a. The edge ring 130 may support the outer lower surface of the semiconductor substrate a. At this time, the edge ring 130 may support the semiconductor substrate a to allow the lower surface thereof to be exposed.

The edgering 130 may include a substrate-supporting stepped-jaw 131 and an edge lower groove 133. The substrate-supporting stepped-jaw 131 may be formed to have various vertical cross-sections. The edge ring 130 may be formed by having the edge lower groove 133 having various shapes, while including the substrate-supporting stepped-jaw 131.

The substrate-supporting stepped-jaw 131 may be formed by extending the edge ring in an outward direction from an upper portion of an inner circumference surface of the edge ring. The substrate-supporting stepped-jaw 131 may be formed to have an inner diameter greater than an outer diameter of the semiconductor substrate a. Accordingly, the substrate-supporting stepped-jaw 131 enables an outer part of the semiconductor substrate a to be stably seated and supported thereon.

The edge lower groove 133 may be formed to have a predetermined depth in an upward direction from a lower surface of the edge ring 130. Furthermore, the edge lower

groove 133 may be formed in the shape of a ring having a predetermined width on an outer side of the substrate-supporting stepped-jaw 131. The edge lower groove 133 may cause a thickness of the edge ring 130 to be uniform throughout.

The edge ring 130 may be formed to have an emissivity per unit area, with respect to a horizontal plane, which is equal to or greater than that of the semiconductor substrate a. To this end, the edge ring 30 may be formed to have a predetermined thickness reflecting the emissivity of the material. For example, the edge ring 130 may be formed from a ceramic material. The edge ring 130 may be formed from SiC material. The edge ring 130 may be formed to have a thickness is less than that of the semiconductor substrate a. For example, when the thickness of the semiconductor substrate a is 0.7mm, the thickness of the edge ring 130 may be 0.4mm. In this case, the semiconductor substrate a and the edge ring 130 may each have the emissivity of 0.6 to 0.7 based on the same thickness, and the emissivity of the edge ring 130 may be 0.7 to 0.8. When a laser beam is irradiated to the air ring under the same condition as the semiconductor substrate a, the degree of temperature reduction of the edge ring 130 may be relatively the same as or similar to that of the semiconductor substrate a.

The substrate support 140 may include an upper support 141 and a lateral support 143. The substrate support 140 may be placed on an outer side of the semiconductor substrate a in an upper portion of the inner housing 120 to support an outer lower surface of the edge ring 130. Also, the substrate support 140 may allow the lower surface of the semiconductor substrate a to be exposed. Further, the substrate support 140 may be extended to the chamber lower space 100b to be coupled with the substrate rotating unit 500. The substrate support 140 may rotate the edge ring 130 and the semiconductor substrate a using an action of the substrate rotating unit 500. A separate hydrogen gas may be supplied to an internal space of the substrate support 140. The hydrogen gas may prevent the process gas from entering the internal space of the substrate support 140. Thus, the hydrogen gas may prevent the process gas from being deposited as a thin film on the lower surface of the semiconductor substrate a.

Although not specifically illustrated, the hydrogen gas may flow into the substrate support 140 through a separate inlet.

The upper support 141 may have an edge ring supporting hole 141a and an edge ring-supporting stepped-jaw 141b formed in an inner part thereof. The upper support 141 may support a lower outer part of the edge ring 130, while exposing the lower surface of the edge ring 130. The upper support 141 may be formed to have a diameter or width greater than that of the edge ring 130.

The edge ring supporting hole 141a may be formed in a central part of the upper support 141 and pass through the upper support 41 from an upper surface and to a lower surface. The edge ring supporting hole 141a may be formed with an inner diameter greater than an outer diameter of the edge ring 130 to support an outer lower part of the edge ring 130.

The edge ring-supporting stepped-jaw 141b may be formed by extending the edge ring in an outward direction from an upper portion of an inner circumference surface of the edge ring supporting hole 141a. The edge ring-supporting stepped-jaw 141b may be formed to have an inner diameter greater than an outer diameter of the edge ring 130. Accordingly, the edge ring-supporting stepped-jaw 141b may allow an outer part of the edge ring 130 to be stably seated and supported.

The lateral support 143 is formed roughly in the shape of a barrel having an opened upper portion and an opened lower portion, and may be formed in a shape corresponding to that of the inner housing 120. For example, when the inner housing 120 is formed in a cylindrical shape, the lateral support 143 may be formed in a cylindrical shape in response to the shape of the inner housing. The lateral support 143 may be placed across the chamber upper space 100a and the chamber lower space 100b. In the lateral support 143, an upper portion may be coupled to an outer part of the upper support 141 and a lower portion is extended to the chamber lower space 100b to be coupled with the substrate rotating unit 500.

Accordingly, the lateral support 143 may be rotated by the substrate rotating unit 500, thereby allowing the upper support 141 to be rotated.

The laser beam transmitting plate 150 may be coupled to an upper portion of the inner housing 120 to seal the upper portion of the inner housing 120. The laser beam transmitting plate 150 may be placed below the semiconductor substrate a. The laser beam transmitting plate 150 may be formed as a transparent plate such as quartz, glass, or the like through which the laser beam is transmitted. The laser beam transmitting plate 150 may provide a passage through which the laser beam irradiated from the substrate heating unit 200 is irradiated to the lower surface of the semiconductor substrate a. The laser beam transmitting plate 150 may be formed to have an area larger than that of the semiconductor substrate a. For example, the laser beam transmitting plate 150 may be formed to have a diameter or width larger than a diameter or width of the semiconductor substrate a.

An upper surface of the laser beam transmitting plate 150 may be divided into a transmissive substrate region 150a, a transmissive edge region 150b, and a transmissive support region 150c. These regions are regions that are defined according to a position relation corresponding to the semiconductor substrate a, the edge ring 130 and the substrate support 140 which are placed thereabove, respectively. The transmissive substrate region 150a may be a region positioned below of the semiconductor substrate a. Also, the transmissive edge region 150b may be a region positioned below the edge ring 130. Furthermore, the transmissive support region 150c may be a region positioned below the substrate support 140. These regions may have zones, respectively, that overlap each other.

The infrared-ray transmitting plate 160 may be formed in a plate shape corresponding to a plane shape of the outer upper wall body 111. The infrared-ray transmitting plate 160 may be formed from a transparent material such as quartz or glass. Below the upper plate 115 below, the infrared-ray transmitting plate 160 may be coupled to an upper inner side of the outer upper wall body 111 in a horizontal direction. The infrared-ray transmitting plate 160

may be placed such that, above the semiconductor substrate a, its lower surface faces the upper surface of the semiconductor substrate a. The infrared-ray transmitting plate 160 may separate an upper interior of the outer upper wall body 111 into upper and lower spaces. That is, the infrared-ray transmitting plate 160 may form the separated cooling gas spraying space 100c above the chamber upper space 100a. The cooling gas spraying space 100c may provide a space into which a cooling gas sprayed from the cooling gas spraying unit 400 flows to come into contact with the infrared-ray transmitting plate 160.

The infrared-ray transmitting plate 160 may transmit radiant energy generated by the semiconductor substrate a during the epitaxial process to the outside. In particular, the infrared-ray transmitting plate 160 may transmit radiant energy of a wavelength including infrared-ray to the outside. Furthermore, the infrared-ray transmitting plate 160 may be maintained at a temperature of 400°C or less, and preferably at a temperature of 300 to 400°C. Since the infrared-ray transmitting plate 160 is maintained at a temperature of 300 to 400°C, deposition achieved by the process gas can be prevented, thereby preventing an increase in emissivity due to deposition. Furthermore, since the emissivity of the infrared-ray transmitting plate 160 is not increased with the number of epitaxial processes, the infrared-ray transmitting plate can reduce difference in deposition temperature between the semiconductor substrates a being processed. Here, the process gas may be varied depending on the type of heat treatment process. For example, in the epitaxial process, gases such as SiH₄, SiH₂Cl₂, SiHCl₃, or SiCl₄ may be used as the process gas. Chemical deposition may be significantly reduced when the temperature of the cooling gas is 400°C or lower. In addition, the emissivity of the infrared-ray transmitting plate 160 is not increased with the number of heat treatment processes, the infrared-ray transmitting plate can reduce difference in process temperature between the semiconductor substrates a on which the process is being performed.

The substrate heating unit 200 may include a device array plate 210 and VCSEL modules 220. As illustrated in FIG. 5, the substrate heating unit 200 may be formed by

arranging the plurality of VCSEL modules 220 on an upper surface of the device array plate 210 in a x-direction and a y-direction.

Within the inner housing 120 of the process chamber 100, the substrate heating unit 200 may be placed below the laser beam transmitting plate 150. The substrate heating unit 200 can irradiate a laser beam to the lower surface of the semiconductor substrate a through the laser beam transmitting plate 150.

An upper surface of the substrate heating unit 200 may be divided into a substrate heating region 200a, an edge heating region 200b, and a support heating region 200c. The substrate heating region 200a, the edge heating region 200b, and the support heating region 200c are regions that are defined according to a position relation corresponding to the semiconductor substrate a, the edge ring 130 and the substrate support 140 which are placed thereabove, respectively. Also, the substrate heating region 200a, the edge heating region 200b, and the support heating region 200c may be regions corresponding to the transmissive substrate region 150a, the transmissive edge region 150b, and the transmissive support region 150c, respectively. The substrate heating region 200a may be a region placed below the semiconductor substrate a. Further, the edge heating region 200b may be a region placed below the edge ring 130. In addition, the support heating region 200c may be a region placed below the substrate support 140. These regions may have zones, respectively, that overlap each other.

The device array plate 210 may be formed in a plate shape having a predetermined area and thickness. The device array plate 210 may preferably be formed to have an area corresponding to the semiconductor substrate a, the edge ring 130 and a predetermined width extending outward from an inner circumference surface of the upper support 141. As mentioned above, an upper surface of the device array plate 210 may be divided into the substrate heating region 200a, the edge heating region 200b and the support heating region 200c. The device array plate 210 may be formed from a thermally conductive ceramic

material or a metallic material. The device array plate 210 may function to dissipate heat generated by the VCSEL module 220.

The VCSEL module 220 may include a device substrate 221, VCSEL devices 223, an electrode terminal 225 and a cooling block 227. The plurality of the VCSEL modules 220 may be arranged in a grid shape and placed on the upper surface of the device array plate 210. On the upper surface of the device array plate 210, the VCSEL modules 220 may be arranged throughout the substrate heating region 200a, the edge heating region 200b, and the support heating region 200c. The VCSEL module 220 may be arranged such that the laser beam is irradiated to the semiconductor substrate a, the edge ring 130, and a region having a predetermined width and extending outward from an inner circumferential surface of the upper support 141. The VCSEL module 220 may heat the semiconductor substrate a, the edge ring 130 and a portion of the upper support 141 with the laser beam emitted from the VCSEL device 223.

The VCSEL module 220 is formed by arranging the plurality of VCSEL devices 223 on the upper surface of the device substrate 221 in the x-axial direction and the y-axial direction. When the VCSEL modules 220 are arranged in the y-axial direction, the terminal region 221b positioned at the other side of a front end portion of the VCSEL module and the terminal region 221b positioned at the one side of a rear end portion of the adjacent VCSEL module 220 may be positioned adjacent to each other in the x-axial direction. In the VCSEL modules 220, the device regions 221a and the terminal regions 221b may be linearly arranged in the x-axial direction, respectively, and the device regions 221a and the terminal regions 221b may be alternately arranged in the y-axial direction.

The device substrate 221 may be formed from a general substrate used for mounting electronic devices. The device substrate 221 may be divided into the device region 221a on which the plurality of VCSEL devices 223 are mounted and the terminal region 221b on which the terminals are mounted. On the device region 221a, the plurality of VCSEL devices

223 may be arranged and mounted in a grid shape. The terminal region 221b is placed adjacent to the device region 221a and a plurality of terminals can be mounted on this terminal region.

The plurality of VCSEL devices 223 are arranged in the x-axial direction and the y-axial direction on the upper surface of the device substrate 221. The VCSEL device 223 can irradiate a laser beam of a single wavelength of 940nm. Since the VCSEL device 223 emits a high-powered laser beam, compared with a conventional halogen lamp, this device can increase the temperature rise rate of the semiconductor substrate a and has a relatively long lifespan.

In the VCSEL device 223, a plurality of micro-emitters may be arranged in the x-axial direction and the y-axial direction. Although not specifically illustrated, the VCSEL device 223 may include a light emitting frame (not shown) for holding the micro-emitters and power lines (not shown) for supplying current to the micro-emitters. The VCSEL device 223 may be configured such that the same current is applied to the whole micro-emitters. Alternatively, the VCSEL device 223 may be configured such that different powers are applied to the micro-emitter, respectively.

The plurality of electrode terminals 225 may be formed on the terminal region 221b of the device substrate 221. The electrode terminals 225 may include a + terminal and a - terminal, and may be electrically connected to the VCSEL device 223. The electrode terminals 225 may be electrically connected to the VCSEL element 223 in a variety of ways, although not specifically shown. The electrode terminals 225 may supply the current required for driving the VCSEL device 223.

The cooling block 227 may be formed to have a planar shape corresponding to a planar shape of the device substrate 221 and a predetermined height. The cooling block 227 may be formed of a thermally conductive ceramic material or metallic material. The cooling block 227 may be coupled to a lower surface of the device substrate 221 by a separate

adhesive layer. The cooling block 227 may dissipate downwardly heat generated by the VCSEL device 223 mounted on a surface of the device substrate 221. Accordingly, the cooling block 227 may cool the device substrate 221 and the VCSEL device 223. Reference number 226 which is not described may be an adhesive layer that bonds the device substrate 221 and the cooling block 227 to each other.

In addition, the cooling block 227 may have a cooling flow passage (not shown), through which cooling water flows, formed therein. The cooling flow passage has an inlet and an outlet formed in a lower surface, and may be formed in various shape within the cooling block.

In the substrate heating unit 200 of another embodiment, depending on the shape in which the VCSEL devices 223 and the electrode terminals 225 are disposed on an upper surface of the device substrate 221, the VCSEL module 220 may be formed in various shapes. Referring to FIG. 5, the VCSEL module 220 according to another embodiment of the present disclosure may be formed in square or rectangular shape as a whole. In the VCSEL module 220, the device region 221a is formed in a quadrangular shape having an entire width and a predetermined length, and the terminal region 221b may be formed at an entire front or rear end of the device region 221a. Furthermore, the terminal region 221b may be formed to have a length smaller than that of the device region 221a.

In the substrate heating unit 200, when the VCSEL modules 220 are arranged on the device array plate 210 in the y-axial direction, the terminal region 221b positioned at a front end and the device region 221a of another VCSEL module 220 positioned in front of the VCSEL module may be adjacent to each other.

In such a case of the substrate heating unit 200, the device regions 221a and the terminal regions 221b of the VCSEL modules 220 are sequentially arranged in the x-axial direction, respectively, and the device regions 221a and the terminal regions 221b are alternately arranged in the y-axial direction.

Referring to FIG. 6, furthermore, the VCSEL module 220 according to another embodiment of the present disclosure may be formed in a roughly rectangular shape. In addition, on the VCSEL module 220, the terminal regions 221b may be formed on the other side of a front end portion and one side of a rear end portion of the quadrangular shape, respectively, and have a rectangular shape having a predetermined length and a width corresponding to a half of the entire width of the VCSEL module. That is, the terminal region 221b may be formed to have a width corresponding to a half of the width of the VCSEL module. The terminal regions 221b may be positioned diagonally to each other in the rectangle. In the VCSEL module 220, a region except for the terminal regions 221b may be formed as the device region 221a.

Further, one side and the other side of the VCSEL module 220 may be formed in a straight line shape. A length of the terminal region 221b may be smaller than that of the device region 221a. The terminal region 221b may be formed to have front and rear sides which have the same length.

When the VCSEL modules 220 are arranged on the device array plate 210 in the y-axial direction, the terminal region 221b positioned at one side of the front end portion may be positioned adjacent to the device region 221a positioned at one side of a rear end portion of another VCSEL module 220 positioned in front of the VCSEL module. When the VCSEL modules 220 are arranged in the y-axial direction, the terminal region 221b positioned at the other side of the rear end portion may be positioned adjacent to the device region 221a positioned at the other side of the front end portion of another VCSEL module 220 positioned in front of the VCSEL module.

In addition, in the VCSEL modules 220, the device regions 221a and the terminal regions 221b are alternately arranged in the x-axial direction on a region on which the terminal regions 221b are formed with respect to the y-axial direction, and the device regions 221a may be linearly arranged in the x-axial direction on a region on which the terminal

region 221b is not formed.

Accordingly, the substrate heating unit 200 includes a region in which the device regions 221a and the terminal regions 221b are alternately arranged in the x-axial direction and a region in which only the device regions 221a are arranged, and the device regions 221a and the terminal regions 221b may be alternately arranged in the y-axial direction.

The beam guiding part 300 may be formed in the form of a bar having a straight line shape, a predetermined length and a predetermined diameter. Furthermore, the beam guiding part 300 may be formed to have a height less than a distance between the upper surface of the laser beam transmitting plate 150 and the lower surface of the edge ring 130. The beam guiding part 300 may be formed such that its central axis is straight and is positioned in an inclined direction with respect to a horizontal plane. At this time, the beam guiding part 300 may be formed such that an upper surface and a lower surface form a horizontal plane and the central axis makes an angle less than 90 degrees with the lower surface. The beam guiding part 300 may be positioned such that the lower surface is positioned on the transmissive support region 150c of the laser beam transmitting plate 150 and the upper surface is adjacent to the lower surface of the edge ring 130 corresponding to the transmissive edge region 150b. Accordingly, the angle between the upper surface and the central axis of the beam guiding part 300 may be determined depending to a distance and a position relation in the horizontal direction between the transmissive support region 150c and the lower surface of the edge ring 130. The beam guiding part 300 may be formed from quartz material.

The beam guiding part 300 may be formed in a cylindrical shape having a circular horizontal cross-section. Also, the beam guiding part 300 may be formed in a polygonal shape such as a square, pentagon, hexagon, or octagon in its horizontal cross-section. Furthermore, the beam guiding part 300 may be formed to have a hollow interior. In addition, the beam guiding part 300 may be formed in a tubular shape with a hollow interior and opened upper and lower ends.

The beam guiding part 300 may be formed so that a diameter or width of the upper surface is equal to or less than a width of the edge ring 130. Here, a width of the edge ring 130 may be a distance corresponding to a difference between an outer diameter and an inner diameter of the edge ring 130. Since the beam guiding part 300 irradiates the laser beam from the upper surface thereof to the lower surface of the edge ring 130, the upper surface may be formed such that a diameter thereof corresponds to the lower surface of the edge ring 130. Further, the beam guiding part 300 may be formed such that the lower surface has an area which is equal to or greater than that of the upper surface. However, the beam guiding part 300 may be formed such that a diameter or width of the lower surface is smaller than a width of the support heating region 200c. Furthermore, the beam guiding part 300 may be formed such that diameters or widths of the upper surface and the lower surface differ from each other.

The beam guiding part 300 can irradiate the laser beam, which is irradiated from the VCSEL module 220 positioned therebelow and is incident thereinto, to the lower surface of the edge ring 130. The beam guiding part 300 may guide the laser beam, which is incident thereinto through the lower surface, to the upper surface while internally reflecting it, and may emit the laser beam to the lower surface of the edge ring 130 through the upper surface thereof. Accordingly, the beam guiding part 300 may cause the laser beam of the VCSEL module 220 to be focused on and irradiated onto the lower surface of the edge ring 130, thereby further heating the edge ring 130. Since the edge ring 130 is further heated by the laser beam, it is possible to reduce the heat of the semiconductor substrate a from being dissipated through the edge ring 130. Thus, the semiconductor substrate a may maintain the same or similar heating temperature from a central region to a peripheral region.

The beam guiding part 300 may be formed in various shapes in other embodiments.

Referring to FIG. 7, the beam guiding part 300 according to another embodiment of the present disclosure has a bar shape, and may be formed such that a central axis thereof

makes a vertical straight line at its lower portion and an inclined straight line at its upper portion. In this case, the upper inclined straight line may make an angle greater than 90 degrees with the vertical straight line. However, even in this case, the lower surface of the beam guiding part 300 may be positioned above the transmissive support region 150c, and the upper surface may be positioned to be adjacent to the lower surface of the edge ring 130. Thus, the beam guiding part 300 may cause the laser beam, which is incident through the lower surface thereof, to be irradiated to the lower surface of the edge ring 130.

Furthermore, referring to FIG. 8, the beam guiding part 300 according to yet another embodiment of the present disclosure has a bar shape, and may be formed such that a central axis thereof makes a lower vertical straight line, an intermediate inclined straight line, and an upper vertical straight line. However, even in this case, the lower surface of the beam guiding part 300 may be positioned above the transmissive support region 150c, and the upper surface may be positioned to be adjacent to the lower surface of the edge ring 130. Thus, the beam guiding part 300 may cause the laser beam, which is incident through the lower surface thereof, to be irradiated to the lower surface of the edge ring 130.

The cooling gas spraying unit 400 may include a spray housing 410 and a gas spraying plate 420. The cooling gas spraying unit 400 may spray cooling gas to the upper surface of the infrared-ray transmitting plate 160 to cool the infrared-ray transmitting plate 160. The cooling gas may be nitrogen (N₂) gas, argon (Ar) gas, or compressed cooling air.

The spray housing 410 may include a cooling gas inlet 411. The spray housing 410 may be formed in the shape of a hollow barrel having an opened lower portion. The spray housing 410 may be formed to have a planar shape corresponding to the upper plate 115 of the outer housing 110. The spray housing 410 may have a cooling gas inflow space 410a formed therein to allow cooling gas to flow thereinto.

The cooling gas inlet 411 may be formed in the hole shape formed in an upper plate or a side plate of the spraying housing 410 and extending from outside to the inside of the

spraying housing, i.e. to the cooling gas inlet space 410a. One or plurality of cooling gas inlets 411 may be formed depending on a planar surface area of the spray housing 410. The cooling gas inlet 411 may provide a flow passage through which the cooling gas flows into the cooling gas inlet space 410a.

The gas spraying plate 420 may include a gas spraying hole 421. The gas spraying plate 420 is formed in a plate shape, and may have an area corresponding to a planar area of the spraying housing 410. The gas spraying plate 420 may be coupled to a lower portion of the spraying housing 410 to shield the lower portion of the spraying housing 410.

The gas spraying hole 421 is formed by passing through the gas spraying plate 420 from an upper surface to a lower surface. The gas spraying hole 421 allows the cooling gas inflow space 410a and the upper through-hole 115a of the upper plate 115 to be in fluid communication with each other. The gas spraying hole 421 may spray cooling gas, which flows into the cooling gas inflow space 410a from the outside, to an inner part of the upper through-hole 115a and the upper surface of the infrared-ray transmitting plate 160.

The plurality of gas spraying holes 421 may be formed such that they are spaced apart from each other throughout the gas spraying plate 420. The gas spraying holes 421 may spray cooling gas uniformly onto the entire upper surface of the infrared-ray transmitting plate 160. Thus, the gas spraying plate 420 may cool the infrared-ray transmitting plate 160, which is placed therebelow, more uniformly.

The substrate rotating unit 500 may include an inner rotating means 510 and an outer rotating means 520. The substrate rotating module 500 may rotate the substrate support 140 in a horizontal direction in a non-contact manner. More specifically, the inner rotating means 510 may be coupled to the lower portion of the substrate support 150 in the chamber lower space 100b of the process chamber 100. In addition, the outer rotating means 520 may be positioned to face the inner rotating means 510 at the outside of the process chamber. The outer rotating means 520 may rotate the inner rotating means 510 in a non-contact manner

using a magnetic force.

The inner rotating means 510 may be formed to have the same structure as a rotor of a motor. For example, the inner rotating means 510 may be formed as a magnet structure that is formed in a ring shape as a whole and has N poles and S poles alternately arranged in a circumferential direction. The inner rotating means 510 may be coupled to the lateral support 143 of the substrate support 140. At this time, the inner rotating means 510 may be positioned to be spaced upward apart from an upper portion of the lower plate 117. Meanwhile, although not specifically illustrated, the inner rotating means 510 may be supported by a separate support means such that the generation of vibration during rotation is prevented or it can be rotated smoothly. For example, a lower portion of the inner rotating means 510 may be supported by a support bearing or a roller.

The outer rotating means 520 may be formed to have the same structure as a stator of a motor. For example, the outer rotating means 520 may include an iron core formed in the shape of ring and an electrically conductive wire wound around the iron core. The outer rotating means 520 can rotate the inner rotating means 510 with a magnetic force generated by power supplied to the electrically conductive wire. The outer rotating means 520 may be placed outside the outer housing 110 such that it faces the inner rotating means 510 with respect to the outer housing 110. In other words, the outer rotating means 520 may be placed outside the outer housing with the respect to the outer housing 110 at the same height as the inner rotating means 510.

The following describes the operation of the semiconductor manufacturing apparatus for the epitaxial process according to one embodiment of the present disclosure. The following description will focus on the operation of the beam guiding part constituting the semiconductor manufacturing apparatus for the epitaxial process.

FIG. 9 is a view showing a result of simulating a guidance direction and irradiation density of the laser beam of the beam guiding part of FIG. 1. FIG. 10 is a view showing a

result of simulating a guidance direction and irradiation density of the laser beam of the beam guiding bar of FIG. 7. FIG. 11 is a view showing a result of simulating a guidance direction and irradiation density of the laser beam of the beam guiding bar of FIG. 8. FIG. 12 is a view showing a result of simulating a guidance direction and irradiation density of the laser beam in the absence of the beam guiding bar.

As depicted in FIG 9, the beam guiding part 300 may focus the laser beam irradiated from the VCSEL module 220 placed below it and to guide the laser beam to its upper surface. The beam guiding part 300 may guide the laser beam, which is irradiated from the VCSEL module 220 positioned in the support heating region 200c, to the lower surface of the edge ring 130 to heat it.

After being irradiated from the VCSEL module 220, the laser beam may be incident into an interior of the beam guiding part 300 through a lower surface thereof, and may be then guided in an upward direction via an internal reflection on a side surface of the beam guiding part 300. Furthermore, the laser beam is not irradiated to an outside through the side surface of the beam guiding part 300, and may be guided in the upward direction. The laser beam may be focused and emitted through an upper surface of the beam guiding part, and is then irradiated to the lower surface of the edge ring 130 to heat the edge ring 130.

The edge ring 130 may be heated by the laser beam irradiated from the VCSEL module 220 placed in the edge heating region 200b and the VCSEL module 220 placed in the support heating region 200c. In other words, the edge ring 130 may be further heated by the laser beam irradiated from the VCSEL module 220 placed in the support heating region 200c. Thus, since the laser beam, which is more than that irradiated to the semiconductor substrate a and the substrate support 140, is irradiated to the edge ring 130 to heat the edge ring, even if the heat of the edge ring 130 is dissipated through the substrate support 140, the heat of the semiconductor substrate a may not be dissipated through the edge ring 130. Since the heat of the outer side of the semiconductor substrate a is not dissipated through the edge ring 130, the

temperature of a central region and an outer region of the semiconductor substrate may be heated uniformly.

As shown in FIGS. 10 and 11, depending on the shape of the beam guiding part 300, the density and region of the laser beam guided to the lower surface of the edge ring 130 are somewhat different, but the beam guiding part may further guide the laser beam irradiated from the VCSEL module 220 placed in the support heating region 200c to the lower surface of the edge ring 130.

In comparison, in the absence of the beam guiding part 300 as shown in FIG. 12, the laser beam may be dispersed and irradiated in a predetermined angular range from an upper surface of the VCSEL module 220. The laser beam irradiated from the VCSEL module 220 is dispersed and irradiated throughout the irradiation range and cannot be irradiated intensively on the required region. The laser beam irradiated from the VCSEL module 220 placed in the support heating region 200c is not intensively irradiated to the lower surface of the edge ring 130, and cannot further efficiently heat the edge ring 130.

The semiconductor manufacturing apparatus 10 may uniformly heat the entire semiconductor substrate a. Therefore, it could be confirmed that, although not specifically illustrated, the semiconductor manufacturing apparatus 10 for the epitaxial process uniformly deposits a Si thin film on an inner region and an outer region of the upper surface of the semiconductor substrate a. It is confirmed that in the process of depositing the Si thin film, the inner region and the outer region are uniformly heated, so that the Si thin film is uniformly deposited on the semiconductor substrate a. In comparison, in the conventional semiconductor manufacturing apparatus 10 for the epitaxial process, the outer region of the semiconductor substrate a is heated to a relatively low temperature, so that a thickness of the Si thin film deposited on the outer region may be thinner than that deposited on the inner region.

In order to help those skilled in the art to understand, the embodiments disclosed

herein are the most preferred embodiments selected from the various implementable embodiments, and are set forth in the present specification. In addition, the technical spirit of the present disclosure is not necessarily restricted or limited only by these embodiments, and various changes, additions, and modification are possible without departing from the technical spirit of the present disclosure, and implementations of other equivalent embodiments are possible.

【CLAIMS】

【Claim 1】

A semiconductor manufacturing apparatus for an epitaxial process, comprising:

a process chamber having an edge ring configured to support an outer lower surface of a semiconductor substrate such that a lower surface of the semiconductor substrate is exposed, a substrate support configured to support an outer lower surface of the edge ring, and a laser beam transmitting plate positioned below the semiconductor substrate;

a substrate heating unit configured to irradiate a laser beam of a VCSEL module to lower surfaces of the semiconductor substrate and the edge ring through the laser beam transmitting plate; and

a beam guiding part configured to irradiate the laser beam of the VCSEL module to the lower surface of the edge ring,

wherein the substrate heating unit is divided into a substrate heating region on which the VCSEL module is placed, an edge heating region, and a support heating region, and

wherein the beam guiding part guides the laser beam irradiated from the VCSEL module positioned on the support heating region to the lower surface of the edge ring.

【Claim 2】

The semiconductor manufacturing apparatus for the epitaxial process of claim 1, wherein the edge ring is extended in an outward direction from an upper portion of an inner circumference surface and has an inner diameter greater than an outer diameter of the semiconductor substrate, and wherein the substrate support comprises an upper support, and the upper support has an edge ring supporting hole having an inner diameter smaller than an outer diameter of the edge ring and an edge ring-supporting stepped-jaw extended in an outward direction from an upper portion of an inner circumference surface of the edge ring supporting hole and having an inner diameter greater than an outer diameter of the edge ring.

【Claim 3】

The semiconductor manufacturing apparatus for the epitaxial process of claim 1, wherein the edge ring has an emissivity per unit area, with respect to a horizontal plane, which is equal to or greater than that of the semiconductor substrate.

【Claim 4】

The semiconductor manufacturing apparatus for the epitaxial process of claim 1, wherein the laser beam transmitting plate has a transmissive substrate region, a transmissive edge region and a transmissive support region corresponding to the substrate heating region, the edge heating region and the support heating region, respectively, and wherein a lower surface of the beam guiding part is positioned on the transmissive support region and an upper surface is positioned below the edge ring.

【Claim 5】

The semiconductor manufacturing apparatus for the epitaxial process of claim 4, wherein the beam guiding part is formed such that the lower and upper surfaces are horizontal surfaces, a central axis is a straight line, and the central axis makes an angle, which is smaller than 90 degrees, with the lower surface.

【Claim 6】

The semiconductor manufacturing apparatus for the epitaxial process of claim 4, wherein the beam guiding part is formed such that a central axis makes a vertical straight line at its lower portion and an inclined straight line at its upper portion, and the inclined straight line and the vertical straight line make an angle greater than 90 degrees with each other.

【Claim 7】

The semiconductor manufacturing apparatus for the epitaxial process of claim 4, wherein the beam guiding part is formed such that a central axis makes a lower vertical straight line, an intermediate inclined straight line and an upper vertical straight line.

【Claim 8】

The semiconductor manufacturing apparatus for the epitaxial process of claim 1,
wherein the beam guiding part is formed from quartz.