CERAMIC HEATER, METHOD OF MANUFACTRUING THE SAME AND DEPOSITION APPARATUS FOR FORMING A THIN LAYER USING THE CERAMIC HEATER

BACKGROUND

1. Field

[0001] Example embodiments relate to a ceramic heater, a method of manufacturing the same and a deposition apparatus for forming a thin layer using the ceramic heater, and more particularly, to a ceramic heater for heating a substrate onto which a thin layer is formed and a method of manufacturing the same and a deposition apparatus for forming a thin layer using the ceramic heater.

2. Description of the Related Art

[0002] Generally, semiconductor devices are generally manufactured through a series of unit processes such as a fab process, an electrical die sorting (EDS) process and a packaging process. Various electric circuits and devices are fabricated on a semiconductor substrate such as a silicon wafer in the fab process, and electrical characteristics of the electric circuits are inspected and defective chips are detected in the wafer in the EDS process. Then, the devices are individually separated from the wafer and each device is sealed in an epoxy resin and packaged into an individual semiconductor device in the packaging process.

[0003] The electric circuits and devices are also formed on the substrate through various unit processes. A thin layer is formed on the substrate by a deposition process and a photoresist pattern is formed on the thin layer. Then, the thin layer is etched off from the substrate in accordance with the photoresist pattern and then the photoresist pattern is removed from the thin layer.

[0004] Recently, a plasma-related process has been widely used for a deposition process

for forming the thin layer so as to reduce the thickness of the thin layer and to improve deposition efficiency. For example, a plasma-enhanced chemical vapor deposition (PECVD) process is most widely known as the plasma-related deposition process.

[0005] A conventional PECVD apparatus includes a process chamber into which processing gases are supplied, plasma electrodes arranged in the process chamber and transforming the processing gases into plasma for a deposition process onto a substrate and a support on which the substrate is positioned in the process chamber.

[0006] The support of the conventional PECVD apparatus includes a ceramic heater for heating the substrate without any electrical influences from surroundings in the process chamber to thereby form the thin layer on the substrate uniformly.

[0007] The ceramic heater comprises ceramic material and includes a plate on which the substrate is substantially arranged and a heating unit installed into an inside of the plate.

[0008] The conventional ceramic heater is manufactured through the following processes. A first ceramic powder is sintered into a first preliminary sinter and a second ceramic powder is sintered into a second preliminary sinter. The heating unit is installed on a surface of the first preliminary sinter, and the first and second preliminary sinters are stacked on each other between which the heating unit is interposed and sintered into the ceramic heater in which the heating unit is installed.

[0009] That is, the conventional ceramic heater is formed through three sintering processes, and thus the manufacturing process for the ceramic heater is complicated and requires high cost.

[0010] In addition, when the first and second preliminary sinters are manufactured into the ceramic heater including the heating unit, a crack or a deformation is generated in the ceramic heater due to a difference of thermal expansion ratio between the heating unit and the preliminary sinters.

SUMMARY

[0011] Example embodiments provide a ceramic heater manufactured by a single sintering process.

[0012] Example embodiments also provide a method of manufacturing the above ceramic heater.

[0013] Example embodiments also provide an apparatus for forming a thin layer on a substrate by a deposition process using the above ceramic heater.

[0014] According to some example embodiments, there is provided a ceramic heater for a deposition apparatus for forming a thin layer. The ceramic heater may include a plate for supporting a substrate and a heating unit that may be installed in an inside of the plate and may generate heat for heating the substrate. For example, the plate may include ceramic materials sintered from a ceramic powder by a single sintering process and the heating unit may be positioned in the ceramic powder during the single sintering process.

[0015] In an example embodiment, the ceramic heater may further include an electrode unit installed in the inside of the plate and electrically grounded to an outside of the plate. For example, the electrode unit may be positioned in the ceramic powder during the single sintering process. The heating unit and the electrode unit may be shaped into one of a mesh plate and a bulk plate.

[0016] In an example embodiment, the heating unit may includes a first heater for heating a central portion of the substrate on the plate and a second heater for heating a peripheral portion of the substrate on the plate. For example, an electric power for heating the substrate may be selectively applied to one of the first and second heaters.

[0017] According to some example embodiments, there is provided a method of manufacturing a ceramic heater. At first, a first ceramic layer may be formed in a

receiving mold by supplying a ceramic powder into the receiving mold of which the upper portion of may be open. A heating unit may be positioned on a surface of the first ceramic layer. A second ceramic layer may be formed on the first ceramic layer to a thickness to cover the heating unit by supplying the ceramic powder onto the first ceramic layer in the receiving mold. A single sintering process may be performed against the ceramic powder in the receiving mold, thereby forming a ceramic body. The single sintering process may be performed to the ceramic powder in the receiving mold at a high temperature, so that the ceramic body may include the heating unit therein.

[0018] In an example embodiment, the single sintering process may be performed against the first and second ceramic layers as follows: A covering mold may be positioned at the opening of the receiving mold, thereby forming a closed space that is defined by the covering mold and the receiving mold and in which the first and second ceramic layers are positioned. Then, the covering mold may be moved toward a bottom portion of the receiving mold, so that the first and the second ceramic layers are pressed to each other in the closed space.

[0019] In an example embodiment, a position of the heating unit along a vertical direction from a bottom portion to the upper portion of the receiving mold is controlled by an amount of the first ceramic powder that is supplied into the receiving mold. The first ceramic layer may be planarized before positioning the heating unit on the surface of the first ceramic layer. In addition, an electrode unit may be further positioned on a surface of the second ceramic layer and a third ceramic layer may be formed on the second ceramic layer to a thickness to cover the electrode unit by supplying the ceramic powder onto the second ceramic layer in the receiving mold. In such a case, the ceramic body may include the heating unit and the electrode unit.

[0020] In an example embodiment, a position of the electrode unit along a vertical direction from a bottom portion to the upper portion of the receiving mold may be controlled by an

amount of the second ceramic powder that is supplied into the receiving mold. The second ceramic layer may be planarized before positioning the electrode unit on the surface of the second ceramic layer.

[0021] According to some example embodiments, there is provided an apparatus for forming a thin layer on a substrate. The apparatus may include a process chamber into which a substrate and reaction gases are supplied, a ceramic heater positioned in the process chamber and a plasma electrode facing the ceramic heater in the process chamber. The substrate may be positioned on the ceramic heater and may be heated by the ceramic heater, and the reaction gases may be transformed into plasma state by a high frequency applied to the plasma electrode. In an example embodiment, the ceramic heater may include a plate for supporting the substrate and a heating unit installed in an inside of the plate and generating heat for heating the substrate. The plate may include ceramic materials sintered from a ceramic powder by a single sintering process and the heating unit may be positioned in the ceramic powder during the single sintering process.

[0022] According to some example embodiments, the ceramic powders may be supplied into the receiving mold many times in such a manner that the heating unit and the electrode unit are covered with the ceramic powders in the receiving mold, and the ceramic powders are formed into a ceramic body including the heating unit and the electrode unit in the receiving mold, thereby reducing manufacturing cost and time of the ceramic heater.

[0023] Further, the ceramic heater may be formed by a single sintering process against the ceramic powder in the receiving mold, thereby preventing boundary surfaces between the conventional preliminary sinters where at least two sintering processes are performed to the preliminary sinters.

[0024] Furthermore, because the heating unit and the electrode unit may be surrounded by the ceramic powders, no thermal stresses may be generated in the heating unit and the

electrode unit during the sintering process, and thus no crack or deformation caused by thermal expansion of the heating unit and the electrode unit may be generated in the ceramic heater.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Example embodiments will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings. FIGS. 1 to 10 represent non-limiting, example embodiments as described herein.

[0026] FIG. 1 is a cross-sectional view illustrating a ceramic heater in accordance with an example embodiment of the present inventive concept;

[0027] FIG. 2 is a plan view illustrating heating unit of the ceramic heater shown in FIG. 1;

[0028] FIG. 3 is a view illustrating an electrode unit of the ceramic heater shown in FIG. 1;

[0029] FIGS. 4A to 4F are cross sectional views illustrating process steps for a method of manufacturing the ceramic heater shown in FIG. 1;

[0030] FIG. 5 is a cross-sectional view illustrating a ceramic heater in accordance with another example embodiment of the present inventive concept; and

[0031] FIG. 6 is a view illustrating a deposition apparatus for forming a thin layer on a substrate in accordance with an example embodiment of the present inventive concept.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0032] Various example embodiments will be described more fully hereinafter with reference to the accompanying drawings, in which some example embodiments are shown. The present invention may, however, be embodied in many different forms and should not be construed as limited to the example embodiments set forth herein. Rather, these example embodiments are provided so that this disclosure will be thorough and complete, and

will fully convey the scope of the present invention to those skilled in the art. In the drawings, the sizes and relative sizes of layers and regions may be exaggerated for clarity.

[0033] It will be understood that when an element or layer is referred to as being "on," "connected to" or "coupled to" another element or layer, it can be directly on, connected or coupled to the other element or layer or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly connected to" or "directly coupled to" another element or layer, there are no intervening elements or layers present. Like numerals refer to like elements throughout. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0034] It will be understood that, although the terms first, second, third etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present invention.

[0035] Spatially relative terms, such as "beneath," "below," "lower," "above," "upper" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the exemplary term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations)

and the spatially relative descriptors used herein interpreted accordingly.

[0036] The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting of the present invention. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0037] Example embodiments are described herein with reference to cross-sectional illustrations that are schematic illustrations of idealized example embodiments (and intermediate structures). As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, example embodiments should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing. For example, an implanted region illustrated as a rectangle will, typically, have rounded or curved features and/or a gradient of implant concentration at its edges rather than a binary change from implanted to non-implanted region. Likewise, a buried region formed by implantation may result in some implantation in the region between the buried region and the surface through which the implantation takes place. Thus, the regions illustrated in the figures are schematic in nature and their shapes are not intended to illustrate the actual shape of a region of a device and are not intended to limit the scope of the present invention.

[0038] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those

defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0039] Hereinafter, example embodiments will be explained in detail with reference to the accompanying drawings.

[0040] FIG. 1 is a cross-sectional view illustrating a ceramic heater in accordance with an example embodiment of the present inventive concept, and FIG. 2 is a plan view illustrating heating unit of the ceramic heater shown in FIG. 1. FIG. 3 is a view illustrating an electrode unit of the ceramic heater shown in FIG. 1.

[0041] Referring to FIGS. 1 to 3, the ceramic heater 100 in accordance with an example embodiment of the inventive concept may include a plate 110, a heating unit 120 and an electrode unit 130.

[0042] A substrate W on which a thin layer is to be formed may be located on the plate 110. The substrate W may include a silicon wafer for a semiconductor device and a thin film transistor (TFT) substrate or a color filter substrate for a flat panel display device.

[0043] The plate 110 may comprise ceramic materials having high heat resistance and electrical insulation property. Examples of the ceramic material may include aluminum nitride (AlN), silicon nitride (Si3N4), silicon carbide (SiC), boron nitride (BN), alumina (Al2O3), etc. These may be used alone or in combinations thereof.

[0044] Therefore, when a thin layer may be formed on the substrate by a deposition process using plasma generated by an external high frequency electric power, the substrate W may be steadily heated by the ceramic heater while the substrate may be prevented from being influenced by the high frequency electric power.

[0045] In an example embodiment, the plate 110 of the ceramic heater 100 may include a ceramic body C that is formed by a single sintering process against ceramic materials

such as a ceramic powder, to thereby prevent boundary portions between the conventional preliminary sinters where at least two sintering processes are performed to the preliminary sinters.

[0046] In an example embodiment, the heating unit 120 may be installed into an inside of the plate 110. The heating unit 120 may be electrically connected to an external power source (not shown). A driving power may be applied to the heating unit 120 from the external power source and heat is generated from the heating unit 120. The heat may be transferred to the substrate W from the heating unit 120 to thereby heat the substrate W.

[0047] In an example embodiment, the heating unit 120 may comprise metal that may generate joule heat. For example, the heating unit 120 may include an alloy including at least about 50% of one of tantalum (Ta), tungsten (W), molybdenum (Mo) and nickel (Ni).

[0048] The heating unit 120 may be positioned in the ceramic powder while the sintering process is performed against the ceramic powder. That is, the sintering process may be performed to the ceramic powder in which the heating unit 120 is laid, and thus the ceramic powder is formed into the ceramic body C of the plate 110 including the heating unit 120.

[0049] In an example embodiment, the heating unit 120 may be positioned in the ceramic powder as a lump or a bulk shape, and thus the heating unit 120 may be clearly distinguished from the ceramics in the ceramic powder. Otherwise, the heating unit 120 may be buried into the ceramic powder as a powder type. In such a case, the powder type heating unit and the ceramic powder may be distinguished by a color thereof.

[0050] For example, the heating unit 120 may include a heating wire 122 shown in FIG. 2. A portion of the bulk type heating unit 120 may be formed into the heating wire 122 and the heating wire 122 may be uniformly distributed on the plate 110 corresponding to a position of the substrate S.

[0051] For example, when the substrate W may be formed into a circular shape like a

wafer, the heating wire 122 may be a concentric circular line distributing on an area corresponding to a whole surface of the substrate W, and thus the substrate W may be uniformly heated along the whole surface thereof.

[0052] In an example embodiment, the electrode unit 130 may be positioned in the ceramic body of the plate 110 and be electrically connected to an external ground unit (not shown). The electrode unit 130 may comprise metal having good electrical conductivity. In the present example embodiment, the electrode unit 130 may comprise material similar to the heating unit 120.

[0053] The electrode unit 130 may be positioned over the heating unit 120 in the plate 110. The electrode unit 130 may also be positioned in a ceramic powder while the sintering process may be performed to the ceramic powder.

[0054] When a thin layer may be formed on the substrate W on the plate 110 by a plasma deposition process using a high frequency voltage, a bias voltage may be applied to the electrode unit 130 for generating plasma in a chamber corresponding to the high frequency voltage.

[0055] In another example embodiment, the electrode unit 130 may be formed into a mesh plate 132 shown in FIG. 3, thus the electrode unit 130 may be distinguished from the ceramic powder in the sintering process.

[0056] In still another example embodiment, the heating unit 120 may be formed into a mesh plate 132 and the electrode unit 130 may be formed into the bulk type.

[0057] Hereinafter, a process for manufacturing the ceramic heater 100 will be described in detail with reference to FIGS. 4A to 4F.

[0058] FIGS. 4A to 4F are cross sectional views illustrating process steps for a method of manufacturing the ceramic heater shown in FIG. 1.

[0059] Referring to FIG. 4A, a first ceramic powder may be supplied into a receiving

mold 30 having an opening at an upper portion thereof, thereby forming a first ceramic layer at a bottom of the receiving mold 30.

[0060] Then, the first ceramic layer C1 may be planarized in the receiving mold 30. For example, the planarization process may be performed by using a press or a vibrator. The first ceramic layer C1 may be pushed down by the press in the receiving mold 30 until a top surface of the first ceramic layer C1 may be planarized. Otherwise, the receiving mold 30 may be horizontally vibrated with respect to a ground until the first ceramic layer C1 in the receiving mold 30 may be planarized. A rotating member may be used in the receiving mold 30 so as to planarize the first ceramic layer C1.

[0061] Referring to FIG. 4B, the heating unit 120 may be positioned on the first ceramic layer C1 of which the top surface is planarized.

[0062] A vertical position of the heating unit 120 in the receiving mold 30 may be varied in accordance with an amount of the first ceramic powder supplied into the receiving mold 30. That is, the more the amount of the first ceramic powder in the receiving mold 30, the greater the gap distance between the surface of the first ceramic layer C1 and the bottom of the receiving mold 30. Therefore, the more the amount of the first ceramic powder is in the receiving mold 30, the higher the vertical position of the heating unit 120 is in the mold layer 30.

[0063] In an example embodiment, the heating unit 120 may be formed into a mesh plate or a bulk type to thereby be distinguished from the first ceramic powder. Otherwise, the heating unit 120 may also be formed into a powder type like the first ceramic powder, as would be know to one of ordinary skill in the art.

[0064] A support member may be installed into the receiving mold 30 so as to prevent the heating unit 120 from slanting or flowing on the first ceramic layer C1 in the receiving mold 30. The first ceramic layer C1 may be compressed by an additional instrument to

such rigidity that is sufficient for securing the heating unit 120 to the surface of the first ceramic layer C1.

[0065] In an example embodiment, many irregularities may be formed on a bottom surface of the heating unit 120 that makes contact with the top surface of the first ceramic layer C1, and thus the area of the contact surfaces between the heating unit 120 and the first ceramic layer C1 may be increased and the heating unit 120 may be sufficiently secured to the first ceramic layer C1.

[0066] A frictional force between the heating unit 120 and the first ceramic layer C1 may be increased in proportion to the area of the contact surfaces to thereby prevent the movement of the heating unit 120 with respect to the first ceramic layer C1. In a modified example embodiment, the heating unit 120 may include at least one leg protruded from a peripheral portion thereof and the leg of the heating unit 120 may be inserted into the first ceramic layer C1 to thereby increase stability of coupling between the heating unit 120 and first ceramic layer C1.

[0067] Referring to FIG. 4C, a second ceramic powder may be supplied onto the first ceramic layer C1 in the receiving mold 30, thereby forming a second ceramic layer C2 on the first ceramic layer C1 to a sufficient thickness to cover the heating unit 120. Therefore, the heating unit 120 may be buried by the second ceramic powder. Then, the second ceramic layer C2 may also be planarized by the same process as the first ceramic layer C1.

[0068] Referring to FIG. 4D, the electrode unit 130, which may be electrically connected to an external ground unit, may be positioned on a top surface of the second ceramic layer C2 to which the planarization process is performed.

[0069] A vertical position of the electrode unit 130 in the receiving mold 30 may also be varied in accordance with an amount of the second ceramic powder supplied into the receiving mold 30 similar to a control on the vertical position of the heating unit 120 in the

receiving mold 30. The electrode unit 130 may also be formed into a mesh plate, a bulk type or a powder type like the heating unit 120.

[0070] In addition, the electrode unit 130 may also be prevented from being slanting or flowing on the second ceramic layer C2 by the same method as the heating unit 120.

[0071] Referring to FIG. 4E, a third ceramic powder may be supplied onto the second ceramic layer C2 in the receiving mold 30, thereby forming a third ceramic layer C3 to a sufficient thickness to cover the electrode unit 130. Therefore, the electrode unit 130 may be buried by the third ceramic layer C3 in the receiving mold 30.

[0072] Referring to FIG. 4F, a covering mold 40 may be positioned at the upper portion of the receiving mold 30 and the first to third ceramic layers C1 to C3, the heating unit 120 and the electrode unit 130 may be located in a closed space defined by the receiving mold 30 and the covering mold 40. Then, a sintering process may be performed to the first to third ceramic layers C1 to C3 in the closed space, and thus the first to third ceramic layers C1 to C3 may be simultaneously sintered into a ceramic body C in the closed space defined by the receiving mold 30 and the covering mold 40.

[0073] For example, a mold assembly of the combination of the covering mold 40 and the receiving mold 30 including the first to third ceramic layers C1 to C3 may be moved into a sintering chamber (not shown) of which the inside is controlled to be high temperature. Then, the covering mold 40 is pressed downwardly to the bottom of the receiving mold 30 under the high temperature, and thus a top surface of the third ceramic layer C3 may be planarized by the covering mold 40. Accordingly, the first to third ceramic layers C1 to C3 may be formed into the single ceramic body C in the mold assembly.

[0074] For example, the covering mold 40 may be pressed at a pressure of about 0.01ton/cm2 to about 0.3ton/cm2 and at a temperature of about 1,600°C to about 1,950°C. The sintering process may be maintained for about 10 hours and the inside of the sintering

chamber may be filled up with inactive gases such as nitrogen gas (N2) and argon (Ar) gas. The process time of the sintering process may be varied in accordance with process conditions and requirements, as would be known to one of ordinary skills in the art.

[0075] In a modified example embodiment, the sintering process may be performed in the sintering chamber without the covering mold 40. The receiving mold 30 including the first to third ceramic layers C1 to C3 without the covering mold 40 may be moved into the sintering chamber that may be kept under the high temperature, to thereby sintering the first to third ceramic layers C1 to C3 into a single ceramic body in the receiving mold 30. In such a case, an additional planarization process may be needed so as to planarize the top surface of the third ceramic layer C3.

[0076] Referring again to FIG. 1, the ceramic body may be separated from the mold assembly or the receiving mold 30, thereby forming the ceramic heater 100 including the heating unit 120 and the electrode unit 130 therein. For example, the receiving mold 30 may be formed into a number of pieces and the separation of the ceramic body may be performed by disassembling of the pieces and the covering mold 40.

[0077] Accordingly, the heating unit 120, the electrode unit 130 and the stacked ceramic layers C1 to C3 in which the heating unit 120 and the electrode unit 130 are positioned may be formed into the ceramic heater 100 by a single sintering process, thereby decreasing the number of processing steps for manufacturing the ceramic heater and reducing manufacturing cost and process time.

[0078] Further, no boundary surfaces, which has been found between preliminary sinters in a conventional manufacturing process due to respective sintering processes to the preliminary sinters, respectively, may be formed between the first to third ceramic layers C1 to C3 in the above manufacturing process of the ceramic heater, because the ceramic heater 100 may be formed by a single sintering process.

[0079] Furthermore, because the heating unit 120 and the electrode unit 130 may be surrounded by the ceramic powder, no thermal stresses may be generated in the heating unit 120 and the electrode unit 130 during the sintering process, so that no crack or deformation caused by thermal expansion of the heating unit 120 and the electrode unit 130 may be generated in the ceramic heater 100.

[0080] While the present example embodiment discusses that both of the heating unit and the electrode unit may be positioned in the ceramic heater, the heating unit, which may be essential for generating heat in the ceramic heater, would be solely positioned in the ceramic heater, as would be known to ordinary skill in the art.

[0081] FIG. 5 is a cross-sectional view illustrating a ceramic heater in accordance with another example embodiment of the present inventive concept.

[0082] The ceramic heater shown in FIG. 5 has the same structure as the ceramic heater in FIG. 1 except the heating unit, and thus in FIG. 5, the same reference numerals denote the same elements in FIGS. 1, 2 and 3 and the detailed descriptions on the same elements will be omitted hereinafter.

[0083] Referring to FIG. 5, the ceramic heater 200 in accordance with another example embodiment of the present inventive concept may include a plate 110, a heating unit 220 and an electrode unit 130, and the heating unit 220 may include a first heater 222 and a second heater 224.

[0084] In an example embodiment, the first and second heaters 222 and 224 may heat a central portion and a peripheral portion of the substrate W that is positioned on the plate 110, respectively. The first and second heaters 222 and 224 may be located at different vertical locations in the ceramic heater 200. For example, the first heater 222 may be located at a vertical position lower than that of the second heater 224.

[0085] The first and second heaters 222 and 224 may be electrically connected to an

external power source (not shown) and thus an electric power for heating the substrate W may be applied to the first and second heaters 222 and 224 from the external power source. For example, the electric power may be selectively applied to one of the first and second heaters 222 and 224 or to both of the first and second heaters 222 and 224.

[0086] Accordingly, the central portion and the peripheral portion of the substrate W may be heated independently from each other by the first and second heaters 222 and 224, and thus a surface temperature of the substrate W may be individually controlled in accordance with a position of the substrate W.

[0087] In a modified example embodiment, one of the first and second heaters 222 and 224 may be electrically connected to the external power source and the first and second heaters 222 and 224 may be electrically connected to each other. In such a case, a controller (not shown) may be additionally interposed between the first and second heaters 222 and 224 so as to selectively connect the first and second heaters 222 and 224 electrically.

[0088] That is, the electric power applied to one of the first and second heaters 222 and 224 may be transferred or not to the other of the first and second heaters 222 and 224 by the controller interposed between the first and second heaters 222 and 224. Example of the controller between the first and second heaters 222 and 224 may include a switching device.

[0089] FIG. 6 is a view illustrating a deposition apparatus for forming a thin layer on a substrate in accordance with an example embodiment of the present inventive concept.

[0090] A ceramic heater in the deposition apparatus of the present example embodiment may have the same structure as one of the ceramic heaters shown in FIGS. 1 and 5, and thus the detailed descriptions on the ceramic heater will be omitted hereinafter. In FIG. 6, the same reference numerals denote the same elements of one of the ceramic heaters shown in FIGS. 1 and 5.

[0091] Referring to FIG. 6, the deposition apparatus 1000 in accordance with an

example embodiment of the present inventive concept may include a process chamber 300, a ceramic heater 100 and a plasma electrode 400.

[0092] In an example embodiment, the process chamber 300 may include a gas injector 310 through which reaction gases including inactive gases such as argon gas may be supplied. Source gases may be additionally supplied into the process chamber 300 through the gas injector 310 or an additional injector (not shown). Examples of the source gas may include silane (SiH4) gas, nitrogen dioxide (NO2) gas, ammonia (NH3) gas and a mixture thereof.

[0093] In an example embodiment, the ceramic heater 100 may be positioned in the process chamber 300, and the substrate W may be loaded onto the ceramic heater 100 from an outside of the process chamber 300. The substrate W may be heated by the ceramic heater 100, and thus the deposition process for forming the thin layer on the substrate W may be efficiently performed in the process chamber 300.

[0094] In an example embodiment, the ceramic heater 100 may be formed by a single sintering process using a ceramic powder, thereby reducing time and cost of manufacturing process for the ceramic heater 100.

[0095] The deposition apparatus may further include a supporting member 500 for supporting the ceramic heater 100. The heating unit 120 and the electrode unit 130 in the plate 110 of the ceramic heater 100 may be electrically connected to the external power source 10 and the external ground unit 20 through the supporting unit 500.

[0096] The plasma electrode 400 may be positioned in the process chamber 300 in such a configuration that the ceramic heater 100 may face the plasma electrode 400. The reaction gases may be transformed into plasma state by a high frequency voltage applied to the plasma electrode 400. Depositing particles for forming the thin layer may be generated from the source gases by the plasma in the process chamber 300.

[0097] In an example embodiment, the plasma electrode 400 may be electrically

connected to an external radio frequency (RF) power source, and thus the high frequency voltage may be applied to the plasma electrode 400 by the RF power source.

[0098] In an example embodiment, the deposition apparatus 1000 may further include a shower head 600 interposed between the ceramic heater 100 and the plasma electrode 400. The source gases and the reaction gases may be uniformly distributed on a whole surface of the substrate W through the shower head 600, and thus the thin layer may be uniformly formed on the whole surface of the substrate W.

[0099] Accordingly, the deposition apparatus 1000 including the ceramic heater 100 may be manufactured by reduced time and cost because the ceramic heater 100 may be manufactured in a reduced time and cost. For example, the deposition apparatus 100 may include a plasma enhanced chemical vapor deposition (PECVD) apparatus.

[00100] According to some example embodiments, the ceramic heater may be formed through a single sintering process, thereby reducing manufacturing cost and time.

[00101] The foregoing is illustrative of example embodiments and is not to be construed as limiting thereof. Although a few example embodiments have been described, those skilled in the art will readily appreciate that many modifications are possible in the example embodiments without materially departing from the novel teachings and advantages of the present invention. Accordingly, all such modifications are intended to be included within the scope of the present invention as defined in the claims. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent structures. Therefore, it is to be understood that the foregoing is illustrative of various example embodiments and is not to be construed as limited to the specific example embodiments disclosed, and that modifications to the disclosed example embodiments, as well as other example embodiments, are intended to be included within the scope of the appended claims.

What is claimed is:

1. A method of manufacturing a ceramic heater, comprising:

forming a first ceramic layer C1 in a receiving mold by supplying a ceramic powder into the receiving mold, a portion of the receiving mold being open;

positioning a heating unit on a surface of the first ceramic layer;

forming a second ceramic layer C2 on the first ceramic layer to a thickness to bury the heating unit therein by supplying the ceramic powder onto the first ceramic layer;

positioning an electrode unit on a surface of the second ceramic layer;

forming a third ceramic layer C3 on the second ceramic layer to a thickness to bury the electrode unit by supplying the ceramic powder onto the second ceramic layer; and

performing a single sintering process against the ceramic powder of the first, the second and the third ceramic layers, thereby forming a ceramic body of the ceramic heater in which cracks or deformation that is caused at boundary surfaces of the first, the second and the third ceramic layers by the difference of thermal coefficients therebetween is prevented.

2. The method of claim 1, wherein the sintering process is performed to the ceramic powder of the first, the second and the third ceramic layers in the receiving mold at a temperature of 1600°C to 1950°C.

3. The method of claim 1, wherein performing the sintering process includes:

positioning a covering mold at the open portion of the receiving mold, thereby forming a closed space that is defined by the covering mold and the receiving mold and in which the first, the second and the third ceramic layers C1, C2 and C3 are positioned; and

pressing the covering mold toward a bottom portion of the receiving mold, so that the first, the second and the third ceramic layers are pressed to each other in the closed space.

4. The method of claim 1, wherein a position of the heating unit is controlled by an amount of the ceramic powder for the first ceramic layer C1 that is supplied into the receiving mold.

5. The method of claim 1, further comprising planarizing the first ceramic layer after forming the first ceramic layer.

6. The method of claim 1, wherein a position of the electrode is controlled by an amount of the ceramic powder for the second ceramic layer that is supplied into the receiving mold.

7. The method of claim 1, further comprising planarizing the second ceramic layer after forming the second ceramic layer.

8. A ceramic heater manufactured by one of claims 1 to 7.