The present invention is one that is intended to prevent bubbles from being recombined to suppress the bubbles from being enlarged, and also homogenize a temperature distribution of a stored liquid source, and provided with: a liquid source container; a first heater that is provided on a side wall of the liquid source container and intended to heat the stored liquid source to a predetermined temperature; a second heater that is provided in an inside central part of the liquid source container and intended to heat the stored liquid source to the predetermined temperature; a plurality of bubble generators that are immersed into the stored liquid source, provided between the second heater and the side wall, and release carrier gas into the liquid source to perform bubbling; and a gas supply pipe that supplies the carrier gas to the bubble generators.
LIQUID SOURCE VAPORIZER

TECHNICAL FIELD

[0001] The present invention relates to a liquid source vaporizer that vaporizes a liquid source by a bubbling method using carrier gas.

BACKGROUND ART

[0002] As this sort of liquid source vaporizer, for example, as disclosed in Patent literature 1, there is one that is provided with: a liquid source container that stores a liquid source; a carrier gas introduction pipe that is intended to bubble the liquid source stored in the liquid source container with use of carrier gas; and a bubbling gas output pipe that is connected to an upper space (gas phase) of the liquid source container and intended to supply gas, which is obtained by the bubbling, to an outside of the liquid source container. Also, a tip part of the carrier gas introduction pipe is immersed into the liquid source, and connected with bubbling nozzles constituted of a plurality of thin tubes. As bubbles generated by the bubbling nozzles float in the liquid source, the liquid source is vaporized into the bubbles, and thereby the vaporized source is supplied outside together with the carrier gas. Also, this vaporizer is configured such that, on an outer surface of the liquid source container, a heater for heating the stored liquid source to a constant temperature is provided to make the liquid source have a homogenized temperature distribution. [0003] However, there is a problem that the bubbles generated by the bubbling nozzles attach to an inner surface of the liquid source container or components inside the container, and this causes the bubbles to be recombined with one another, thereby enlarging the bubbles. If the bubbles are enlarged as described, a ratio of the liquid source that is vaporized into the bubbles is decreased, and the liquid source cannot be saturated in the bubbles, which reduces vaporization efficiency.

[0004] Also, if the liquid source container is large-sized, there occurs a problem that a migration area of the bubbles generated by the bubbling nozzles is limited to part of the container, so that a stirring effect on the liquid source by the bubbles is not obtained, and therefore it is difficult to keep a temperature distribution of the liquid source homogenized. In addition, if the liquid source container is increased in size, there also occurs a problem that, by only providing the heater on the outer surface of the liquid source container, it is not easy to heat the liquid source such that it has a homogenized temperature distribution. It is also thought that by providing the bubbling nozzles such that the bubbles hit against the inner surface of the liquid source container, the liquid source is stirred; however, as described above, there occurs the problem that the bubbles attach to the inner surface of the liquid source, and this causes the bubbles to be recombined with one another, thereby enlarging the bubbles.

CITATION LIST

Patent Literature

[0005] Patent literature 1: Japan patent laid-open number 06-267852

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

[0006] Therefore, the present invention is made to solve the above problems at once, and has a main desired object to prevent bubbles from being recombined to suppress the bubbles from being enlarged, and also to homogenize a temperature distribution of a stored liquid source.

Solution to Problem

[0007] That is, a liquid source vaporizer according to the present invention is provided with: a liquid source container that is configured to store a liquid source; a first heater that is provided on at least a side wall of the liquid source container and is configured to heat the stored liquid source; a second heater that is provided inside the liquid source container and is configured to heat the stored liquid source; a plurality of bubble generators that are configured to immerse into the stored liquid source, provided between the second heater and the side wall, and are configured to release carrier gas into the liquid source to perform bubbling; and a gas supply pipe that is configured to supply the carrier gas to the bubble generators.

[0008] If so, on the side wall and in an inside central part of the liquid source container, the first and second heaters are respectively provided, and therefore a temperature distribution of the liquid source stored in the liquid source container can be easily homogenized. Also, the bubble generators are provided between the second heater and a side wall inner surface, and therefore bubbles can be prevented from easily coming into contact with the second heater and side wall inner surface, and also from being enlarged by the attachment of the bubbles to them. Further, convection can also be formed in the liquid source container to thereby stir the liquid source. Still further, by providing the plurality of bubble generators, even if the liquid source container is large-sized, a stirring effect on the liquid source can be sufficiently produced by the bubbles generated by the respective bubble generators, and thereby the temperature distribution of the stored liquid source can be easily homogenized.

[0009] The plurality of bubble generators are provided such that the bubbles generated by the plurality of bubble generators pass in the vicinity of the side wall inner surface of the liquid source container and in the vicinity of the second heater, and therefore the temperature distribution of the liquid source can be further homogenized by the bubbles generated by the bubble generators while preventing the bubbles from being easily attached to the side wall inner surface of the liquid source container and second heater. The vicinity of the second heater refers to a temperature gradient region generated between the second heater and the liquid source, and a location that, in a state where the bubbles are generated, just enables an influence due to the attachment of the bubbles to the second heater to be substantially ignored. The vicinity of the side wall inner surface refers to a temperature gradient region generated between the side wall inner surface and the liquid source, and a location that, in the state where the bubbles are generated, just enables an influence due to the attachment of the bubbles to the side wall inner surface on vaporization efficiency or the like to be substantially ignored.

[0010] Also, in order to further homogenize the temperature distribution of the liquid source, the plurality of bubble generators are desirably provided radially around a central axis of the liquid source container at regular intervals.

[0011] In order to homogenize the temperature distribution of the liquid source with accuracy by making bubbles generated by the respective bubble generators constant, desirably, the plurality of bubble generators are ones having the same configuration, and the gas supply pipe is provided with a
constant flow rate device that is intended to supply the carrier gas having a constant flow rate to the plurality of bubble generators.

Advantageous Effects of the Invention

According to the present invention configured as described, the bubbles can be prevented from being recombined to suppress the bubbles from being enlarged, and also a temperature of the liquid source stored in the liquid source container can be homogenized.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an overall configuration diagram of a liquid source vaporizer according to one embodiment of the present invention.

FIG. 2 is a schematic diagram illustrating an arrangement mode of bubble generators of the same embodiment.

FIG. 3 is a diagram illustrating a temperature distribution of a liquid source between a side wall inner surface and a second heater.

FIG. 4 is cross-sectional view illustrating a branch pipe and a pipe fitting of the bubble generator of the same embodiment.

FIG. 5 is a diagram schematically illustrating a liquid source vaporizer according to a variation.

REFERENCE CHARACTERS LIST

100: Liquid source vaporizer
2: Liquid source container
3: First heater
4: Second heater
5: Bubble generator
6: Gas supply pipe

DESCRIPTION OF EMBODIMENTS

One embodiment of a liquid source vaporizer according to the present invention will hereinafter be described with reference to the drawings.

A liquid source vaporizer 100 according to the present invention is one that vaporizes, on the basis of a bubbling method, a liquid source serving as a deposition source for a deposition apparatus using a CVD method or the like, and supplies the vaporized source to the deposition apparatus, and as illustrated in FIG. 1, is provided with: a liquid source container 2 that stores the liquid source such as tetraethoxysilane (TEOS); first heaters 3 that are provided on a side wall, an upper wall, and a lower wall of the liquid source container 2, and intended to heat the stored liquid source to a predetermined temperature; a second heater 4 that is provided in an inside central part of the liquid source container (tank) 2, and intended to heat the stored liquid source to the predetermined temperature; a plurality of bubble generators 5 that are immersed into the stored liquid source, provided between the second heater 4 and the side wall, and release carrier gas into the liquid source to perform bubbling; and a gas supply pipe 6 that supplies the carrier gas such as nitrogen or argon to the bubble generators 5.

The liquid source container 2 is an airtight container that is of a substantially rotational body shape and made of stainless steel, and an upper space (air phase) formed in a state where the liquid source is stored is connected with a gas lead-out pipe 7 for supplying vaporized liquid source after the bubbling together with the carrier gas to a deposition apparatus (not illustrated). Note that FIG. 1 illustrates a diagram in which the gas lead-out pipe 7 is connected to the upper wall of the liquid source container 2.

The first heaters 3 are provided in contact with or close to entire outer surfaces of the side wall, upper wall, and lower wall of the liquid source container 2. Also, the second heater 4 is provided in the inside central part of the liquid source container 2 so as to extend in an up-and-down direction and be supported by the upper wall. In addition, the first heaters 3 and the second heater 4 are, in order to heat the liquid source to the predetermined temperature (e.g., 500°C), elevated in temperature to the same temperature (e.g., 50°C) by an unillustrated control part.

Each of the bubble generators 5 is one that releases the carrier gas into the liquid source to form a number of bubbles each having a predetermined diameter, and configurations of the respective bubble generators 5 are the same. The diameter of the bubble is one that depends on a floating distance and just enables the liquid source to be vaporized and saturated into the bubble, and may be, for example, approximately 1 mm. Also, a flow rate of the carrier gas supplied to bubble generators 5 is determined by an after-mentioned mass flow controller (MFC). 8 and a constant flow rate device.

Also, the bubble generators 5 are provided in the vicinity of a bottom part of the liquid source container 2, and specifically, provided on a lower side of the second heater 4 so as to be positioned on a diameter direction outer side of the second heater 4. More specifically, the bubble generators 5 are provided such that the bubbles generated by the bubble generators 5 pass in the vicinity of a side wall inner surface of the liquid source container 2 and in the vicinity of the second heater 4. In the present embodiment, the bubble generators 5 are, as illustrated in FIG. 2, provided, between the second heater 4 and the side wall of the container 2, in ranges from the vicinity of the second heater 4 to the vicinity of the side wall of the container 2. That is, the bubble generators 5 are provided so as not to, in vertical projection, mutually overlap with the second heater 4 or the container 2 side wall. Further, the bubble generators 5 are, as illustrated in FIG. 2, provided radially around a central axis C of the liquid source container 2 at regular intervals.

Note that, as illustrated in FIG. 3, the vicinity of the second heater 4 refers to a temperature gradient region ("a second heater side temperature gradient region" in FIG. 3) generated between the second heater 4 and the liquid source, and a location that, in a state where the bubbles are generated, just enables an influence due to the attachment of the bubbles to the second heater 4 to be substantially ignored. The vicinity of the side wall inner surface refers to a temperature gradient region ("a side wall side temperature gradient region" in FIG. 3) generated between the side wall inner surface and the liquid source, and a location that, in the state where the bubbles are generated, just enables an influence due to the attachment of the bubbles to the side wall inner surface on vaporization efficiency and the like to be substantially ignored. Each of the temperature gradient regions refers to a region where, at a liquid level of the liquid source or at a predetermined depth in the liquid source, a temperature of the liquid source is changed with horizontally increasing distance from the heater 3 or 4. Note that FIG. 3 illustrates a temperature distribution of the liquid source at a predetermined depth X and corresponding temperature gradient regions.
The temperature gradient region generated between the second heater 4 and the liquid source is different between operation start time of the second heater (heating start time) and heating stability time, and the temperature gradient region at the heating stability time is narrower than that at the operation start time. Accordingly, in order to bring the bubble generators 5 as close to the second heater 4 as possible, one end of each of the bubble generators 5 is preferably provided within the temperature gradient region generated between the second heater 4 and the liquid source at the heating stability time. Also, the temperature gradient region generated between the side wall inner surface and the liquid source is different between operation start time of the first heaters 3 (heating start time) and heating stability time, and the temperature gradient region at the heating stability time is narrower than that at the operation start time. Accordingly, in order to bring the bubble generators 5 as close to the side wall inner surface as possible, the other ends of the bubble generators 5 are preferably provided within the temperature gradient region generated between the side wall inner surface and the liquid source at the heating stability time.

The gas supply pipe 6 is provided by being inserted through the upper wall of the liquid source container 2, and in the present embodiment, provided along the second heater 4. Specifically, the gas supply pipe 6 is provided by being inserted through the upper wall of the liquid source container 2, and includes: main pipe 61 that extends along the second heater 4 to below a lower end of the second heater 4; and a plurality of branch pipes 62 that are formed by branching the main pipe 61 at a lower end of the main pipe 61 and extend in radial directions of the liquid source container 2.

The main pipe 61 is provided such that a pipe axis thereof is substantially parallel to the central axis C of the liquid source container 2, and branched such that the branch pipes 62 are provided radially in directions substantially orthogonal to the pipe axis of the main pipe 61 and also at the regular intervals in the radial directions. Also, tips of the branch pipes 61 are connected with the bubble generators 5, respectively. That is, the gas supply pipe 6 is configured to be branched on a lower side of the lower end of the heater 4. In addition, the main pipe 61 is provided with: the mass flow controller (MFC) 8 for controlling a flow rate of the carrier gas; and a preheater 9 for preheating the carrier gas.

As described, an upper side of the bubble generators 5 is configured such that piping only including the main pipe 61 is present, so that a piping configuration on the upper side of the bubble generators 5 can be simplified, and the bubbles generated by the bubble generators 5 can be suppressed from coming into contact with the piping as much as possible.

Also, each of the branch pipes 62 and corresponding bubble generator 5 are, as illustrated in FIG. 4, connected to each other through a pipe fitting 10 such as a VCR fitting. Also, by decreasing an opening diameter of an annular metallic sealing material (gasket) 11 provided inside the pipe fitting 10, an orifice serving as the constant flow rate device is configured. The pipe fittings 10 between the respective branch pipes 62 and the corresponding bubble generators 5 have the same configuration, and the sealing materials 11 inside the pipe fittings 10 also have the same configuration. On this basis, supply flow rates of the carrier gas supplied to the respective bubble generators 5 are configured to be the same.

Note that the present invention is not limited to the above-described embodiment.

For example, in the above-described embodiment, the carrier gas supply pipe is configured to have the one main pipe and the plurality of branch pipes; however, the present invention may be configured such that, without branching the carrier gas supply pipe, each of the bubble generators is provided with one carrier gas supply pipe. Also, the present invention may be configured such that a plurality of bubble generators are treated as a group, and the same carrier gas supply pipe as that in the above-described embodiment is provided for each group.

Also, a connecting position of the carrier gas supply pipe is not limited to the upper wall of the liquid source container, but may be the side wall or the lower wall.

Further, in the above-described embodiment, the constant flow rate device provided for each of the branch pipes of the carrier gas supply pipe is configured with use of the sealing material provided inside the VCR fitting; however, besides, the constant flow rate device may be provided on each of the branch pipes.

In addition, as illustrated in FIG. 5, the present invention may be configured such that, in a state where a plurality of bubble generators are treated as a group, a carrier gas supply pipe 6A or 6B is provided for each group, and switching valves V are provided for the respective supply pipes 6A and 6B, the liquid source is vaporized with switching between the supply pipes 6A and 6B. In this case, the present invention is configured such that a pressure sensor P that measures a pressure inside each of the supply pipes 6A and 6B is provided, and if a pressure inside one of the supply pipes in use is increased to a predetermined value or more, on the assumption that there is a problem of clogging of any of the bubble generators 5, the supply pipe is switched to the other supply pipe to thereby generate bubbles. Note that FIG. 5 illustrates a configuration in which the respective carrier gas supply pipes 6A and 6B merge on an upstream side, and at a point of the merging, the pressure sensor P is provided to measure a pressure. If so, in the case where a problem occurs, such as clogging of a bubble generator provided for one of the carrier gas supply pipes, by switching the carrier gas supply pipe to the other carrier gas supply pipe, long-term operation can be performed.

The liquid source vaporizer in the above-described embodiment is configured to use the plurality of bubble generators; however, besides, the liquid source vaporizer may be
configured to use one ring-like (e.g., annular) bubble generator to surround the second heater.

[0043] In addition, the above-described embodiment has the four bubble generators; however, the number of bubble generators can be appropriately changed depending on a flow rate of the carrier gas, or a configuration of the liquid source container, such as a size or a shape.

[0044] Further, the above-described embodiment is adapted to radially provide the bubble generators at the regular intervals; however, an arrangement mode of the bubble generators can be appropriately changed depending on a configuration inside the liquid source container.

[0045] Also, even if the liquid source vaporizer in the above-described embodiment does not have the second heater 2, it can vaporize the liquid source; however, if the liquid source container is increased in size, vaporization efficiency is reduced. On the other hand, if the liquid source container is small-sized, the liquid source can be sufficiently vaporized only with the first heaters. That is, in the case where the liquid source container is small-sized, the liquid source vaporizer is desirably configured to be provided with: a liquid source container that stores a liquid source; a heater that is provided on at least a side wall of the liquid source container and intended to heat the stored liquid source; a plurality of bubble generators that are immersed into the stored liquid source and intended to release carrier gas into the liquid source to perform bubbling; and a gas supply pipe that supplies the carrier gas to the bubble generators, wherein the plurality of bubble generators are provided such that bubbles generated by the plurality of bubble generators pass in a vicinity of a side wall inner surface of the liquid source container.

[0046] Furthermore, it should be appreciated that the present invention is not limited to any of the above-described embodiments, and can be variously modified without departing from the scope thereof.

INDUSTRIAL APPLICABILITY

[0047] According to the present invention, bubbles can be prevented from being recombined to suppress the bubbles from being enlarged, and also a temperature of a liquid source stored in a liquid source container can be homogenized.

1. A liquid source vaporizer comprising:
   a liquid source container that is configured to store a liquid source;
   a first heater that is provided on at least a side wall of the liquid source container and is configured to heat the stored liquid source;
   a second heater that is provided inside the liquid source container and is configured to heat the stored liquid source;
   a plurality of bubble generators that are configured to immerse into the stored liquid source, provided between the second heater and the side wall, and are configured to release carrier gas into the liquid source to perform bubbling; and
   a gas supply pipe that is configured to supply the carrier gas to the bubble generators.

2. The liquid source vaporizer according to claim 1, wherein
   the plurality of bubble generators are provided such that bubbles generated by the plurality of bubble generators pass in a vicinity of a side wall inner surface of the liquid source container and in a vicinity of the second heater.

3. The liquid source vaporizer according to claim 1, wherein
   the plurality of bubble generators are provided radially around a central axis of the liquid source container at regular intervals.

4. The liquid source vaporizer according to claim 1, wherein
   the plurality of bubble generators are ones having a same configuration, and the gas supply pipe is provided with a constant flow rate device that is configured to supply the carrier gas having a constant flow rate to the plurality of bubble generators.