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(54) Title: AMPOULE SPLASH MITIGATION

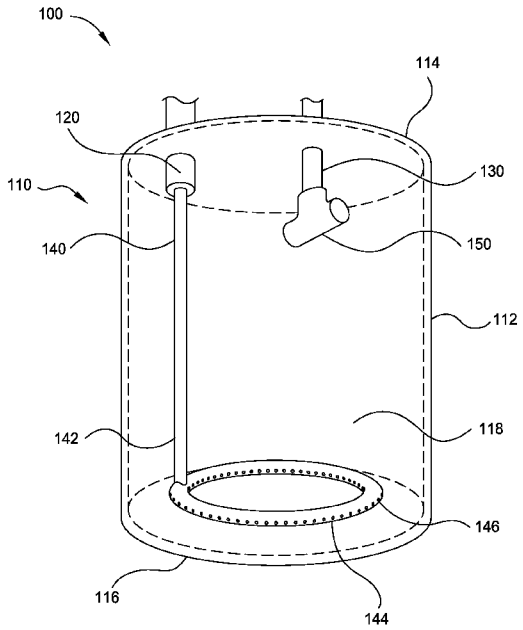


FIG. 1

(57) Abstract: An ampoule having a container, an inlet port, an outlet port, splashguard and a diffuser. The diffuser is disposed within a cavity of the container and comprises a feed tube and a nozzle. The feed tube is coupled to the inlet port and the nozzle is coupled to the feed tube. The nozzle has a closed ring shape and comprises a plurality of holes. A centerline of each of the plurality of holes is oriented at or below a horizontal line of the nozzle to direct fluid away from a lid of the container. The splashguard is coupled to an output port of the ampoule.

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AMPOULE SPLASH MITIGATION

BACKGROUND

Field

[0001] Embodiments described herein generally relate to reducing splashes within an ampoule.

Description of the Related Art

[0002] In many instances, ampoules provide a vaporized precursor material to a process system for the processing of a substrate. For example, a carrier gas may be flowed into the ampoule, as the ampoule is heated, to agitate the precursor and to cause the vaporized precursor to flow through an output of the ampoule. Further, to achieve higher output rates, the rate at which the carrier gas is provided to the ampoule is increased. However, increasing the rate at which the carrier gas is provided to the ampoule may overly agitate the precursor material, causing splashes. If the splashes reach the output port of the ampoule, the splashes may prevent, or at least, limit the flow of the vaporized precursor out of the ampoule, and processing of the corresponding substrate may be detrimentally impacted.

[0003] Thus, there is a need for an improved ampoule that reduces the splashes within an ampoule.

SUMMARY

[0004] In an embodiment, an ampoule comprises a container, an inlet port, output port, a diffuser and a splashguard. The container comprises a bottom, a sidewall and a lid enclosing a cavity. The diffusor is coupled to the inlet port and is disposed within the cavity and comprises a feed tube and a nozzle. The feed tube is coupled to the inlet port and the nozzle is coupled to the feed tube. The nozzle has a closed ring shape and comprises a plurality of holes. A centerline of each of the plurality of holes is oriented at or below a horizontal line of the nozzle. The splashguard is coupled to the output port.

[0005] In an embodiment, an ampoule comprises a container, an inlet port, an output port and a diffuser. The container comprises a bottom, a sidewall and a lid enclosing a cavity. The diffuser is coupled to the inlet port and is disposed within the cavity and comprises a feed tube and a nozzle. The feed tube is coupled to the inlet port and the nozzle is coupled to the feed tube. The nozzle has a closed ring shape and comprises a plurality of holes. An inner diameter of the nozzle is greater than an inner diameter of the feed tube. The splashguard is coupled to the output port.

[0006] In an embodiment, an ampoule comprises a container, an inlet port, an output port, a diffuser, and a splashguard. The container comprises a bottom, a sidewall and a lid enclosing a cavity. The diffusor is coupled to the inlet port and is disposed within the cavity and comprises a feed tube and a nozzle. The feed tube is coupled to the inlet port and the nozzle is coupled to the feed tube. The nozzle comprises a plurality of holes and a cross-section area of the plurality of holes is larger than an inner diameter of the feed tube. The splashguard is coupled to the output port.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this disclosure and are therefore not to be considered limiting of its scope, for the disclosure may admit to other equally effective embodiments.

[0008] Figure 1 illustrates a portion of an ampoule, according to one or more embodiments.

[0009] Figure 2 illustrates a front view of a nozzle, according to one or more embodiments.

[0010] Figure 3 illustrates a perspective view of a nozzle, according to one or more embodiments.

[0011] Figure 4 illustrates a cross-section of a nozzle, according to one or more embodiments.

[0012] Figure 5 illustrates a cross-section of a nozzle and a feed tube, according to one or more embodiments.

[0013] Figure 6 illustrates a splashguard, according to one or more embodiments.

[0014] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements disclosed in one embodiment may be beneficially utilized on other embodiments without specific recitation.

DETAILED DESCRIPTION

[0015] Described herein are ampoules having improved efficiency. Ampoules may commonly be used to provide precursor material to a process system for the processing of a substrate. For example, an ampoule converts a liquid precursor, through a bubbling action of a carrier gas in the presence of heat such, to a vaporized state. The vaporized precursor flows out of an output port of the ampoule and to a connected process system. However, as the bubbling action is applied to the liquid precursor, the force at which the carrier gas is applied to the liquid precursor may cause the liquid precursor to become overly agitated, generating splashes within the ampoule. A splashguard is provided to substantially prevent splashes from entering the output port, and limiting the amount of vaporized precursor that may flow out of the ampoule. Thus, the ampoule with the splashguard advantageously limits splashes within the ampoule which enhances processing of substrates.

[0016] Figure 1 illustrates ampoule 100, according to one or more embodiments. The ampoule 100 comprises a container 110, an inlet port 120, an output port 130, a diffuser 140, and splashguard 150. The ampoule 100 may be used with semiconductor

manufacturing precursors. For example, the ampoule 100 may be utilized to provide a precursor during the processing of a substrate. The ampoule 100 may provide the precursor to a process chamber to deposit a material on a substrate, for example by an atomic layer deposition (ALD) process. The liquid precursor is vaporized within the ampoule 100 by a combination of heat and agitation, to provide the vaporized precursor to the process chamber. The term "precursor" is used to describe liquid compounds vaporized in the ampoule 100 that may be flowed from the ampoule 100 into a process chamber or other process environment in a vaporized state for use in a deposition or other semiconductor fabrication process.

[0017] The container 110 may include sidewall 112, lid 114 and bottom 116 defining a cavity 118. The lid 114 may be secured to the sidewall 112 to fully enclose cavity 118 except for one or more ports. For example, the inlet port 120 and output port 130 may pass through the lid 114. Further, one or more other ports may be placed within one or more of the sidewall 112, the lid 114 and the bottom 116. For example, a refill port may be placed within the sidewall 112 or the lid 114 and utilized to refill the container 110 with additional liquid precursor.

[0018] The container 110 may be substantially cylindrical in shape. Alternatively, the container 110 may have other shapes.

[0019] The lid 114 may be a separate component from the sidewall 112 and attached to the sidewall 112 to define the cavity 118. For example, the lid 114 may connected to the sidewall 112 through a welding process or through the use of one or more bolts or other connecting devices. While not shown, a sealing member may be disposed between the lid 114 and the sidewall 112 to prevent leakage. The sealing member may be an O-ring or other seal.

[0020] The inlet port 120 provides a connection to an external carrier gas source. Further, the inlet port 120 provides a passageway for carrier gasses to flow through the lid 114 and into the cavity 118. The inlet port 120 may include an inlet valve that controls the flow of gasses through the inlet port 120 into the cavity 118.

[0021] The output port 130 allows a vaporized precursor to flow from the cavity 118 to a process chamber or other environment through one or more gas lines. Further, the output port 130 may provide a passageway for gasses to flow out of the cavity 118 and through the lid 114. The inlet port 120 may include an outlet valve that controls the flow of gasses through the output port 130.

[0022] The diffuser 140 may be coupled to the inlet port 120 and may provide a path for gas to flow from an external source to the cavity 118. The diffuser 140 may include feed tube 142 and nozzle 144. The feed tube 142 may be coupled to the inlet port 120 and the nozzle 144, and allows a carrier gas to flow from the inlet port 120 and the nozzle 144. The feed tube 142 may be substantially parallel to the sidewall 112, i.e., the feed tube 142 may have a substantially vertical orientation. Alternatively, one or more portions of the feed tube 142 is non-parallel to the sidewall 112.

[0023] The nozzle 144 is coupled to the feed tube 142. The nozzle 144 may form a complete, continuous ring. Alternatively, the nozzle 144 may have other shapes.

[0024] Further, the nozzle 144 comprises holes 146. The nozzle 144 may be disposed proximate the bottom 116 of the container 110. Further, the nozzle 144 may provide a path for a carrier gas to be carried and released at the bottom 116 of the container 110 to agitate the precursor contained within the cavity 118. The agitated precursor becomes vaporized such that the vaporized precursor flows through the output port 130.

[0025] The nozzle 144 may be configured to reduce splash generation within the ampoule 100. For example, the nozzle 144 may comprises holes 146 distributed over one or more portions of the nozzle 144. One or more of the size and location of the holes 146 may be configured to increase the efficiency of the carrier gas. The small bubbles of the carrier gas may have a combined surface area that is larger than larger bubbles, which reduces splashes caused by the bubbles and increase efficiency of the carrier gas. Increasing efficiency of the carrier gas may correspond to decreasing the amount of carrier gas that is required to cause the vaporized precursor liquid to flow out of the cavity 110 through the output port 130.

[0026] As shown in Figures 2 and 3, the holes 146 may be distributed over one or more of a bottom portion 224 of the nozzle 144, an interior portion 228 of the nozzle, an exterior portion 226 of the nozzle 144. The top portion 222 of the nozzle 144 may be free from holes 146. Such a configuration may reduce splash generation as compared to other nozzles as the carrier gas is directed away from the top (e.g., lid 114) of the container 110. Stated differently, the holes 146 are arranged such that the average vector of gas exiting the holes has no directional component toward the lid 114.

[0027] The diameter of the holes 146 may be selected to diffuse the carrier gas while reducing splashes within the ampoule 100. For example, each of the holes 146 may have a diameter in a range of about 10 mm to about 40 mm. Further, each of the holes 146 on each portion of the nozzle 144 may have a substantially similar diameter. Alternatively, the holes on a first portion of the nozzle 144 may have a first diameter, and the holes on a second portion of the nozzle 144 may have a second diameter, different than the first. Further, the holes on a first portion of the nozzle 144 may have a common diameter, and one or more of the holes on a second portion of the nozzle 144 differ in diameter.

[0028] The holes 146 on each portion of the nozzle 144 may be equally spaced on the nozzle 144. For example, the distance between the holes 146 may be in a range of about 4 mm to about 8 mm. Alternatively, the distance between the holes 146 may be less than about 4 mm or greater than about 8mm. Further, the holes on a first portion of the nozzle 144 may be spaced differently than the holes on a second portion of the nozzle 144. For example, the holes on the interior portion 228 may be spaced differently than the holes on the exterior portion 226 and/or the bottom portion 224.

[0029] The total number of holes 146 may in a range of about 100 holes to about 300 holes. Alternatively, the total number of holes 146 may be less than about 100 or may exceed 300 holes. Further, each portion (e.g., the interior portion 228, the exterior portion 226 and the bottom portion 224) of the nozzle 144 may have a common number of holes, or at least one portion of the nozzle 144 may have more holes than another portion of the nozzle 144. For example, one or more of the interior portion 228, the

exterior portion 226 and the bottom portion 224 may have more holes 146 than another one of the interior portion 228, the exterior portion 226 and the bottom portion 224.

[0030] Figure 4 illustrates a cross-section of nozzle 144. As illustrated, the nozzle 144 includes a hole 146a disposed along the exterior portion 226, a hole 146b disposed along the interior portion 228, and a hole 146c disposed along the bottom portion 224. Further, the top portion 222 is free from any holes. The holes 146 may be configured to flow a carrier gas toward away from the lid 114 of the container 110. For example, a centerline of each hole 146 may be oriented at or below the horizontal line 410 of the nozzle. As is illustrated in Figure 4, the holes 146a and 146b are disposed such that a center of each hole is oriented along the horizontal line 410 of the nozzle 144. Stated another way, the centerline of each hole 146a and 146b are parallel to the horizontal line 410. Further, the holes 146a and 146b may be evenly spaced between the top portion 222 and bottom portion 225.

[0031] The nozzle 144 may additionally include holes 146e and/or 146d. The centerlines of each of holes 146d and 146e are oriented between horizontal line 410 and vertical line 420, such that each hole 146d and 146e faces away from the top portion 222. Further, at least one of the size, number, and spacing of the holes 146 may be configured such that the combined cross-section area of all of the holes 146 is larger than the diameter 510 of the feed tube 142.

[0032] The nozzle 144 may have an inner diameter different than the inner diameter of the feed tube 142. For example, as shown in Figure 5, the feed tube 142 may have diameter 510 and the nozzle 144 may have diameter 520, where diameter 510 is less than diameter 520. The diameter 510 may be in a range of about 4 mm to about 8 mm, and the diameter 520 may be in the range of about 10 mm to 15 mm.

[0033] Figure 6 illustrates the splashguard 150. The splashguard 150 may be attached to the output port 130. For example, the splashguard 150 may be fitted to the output port 130, such that the output port 130 at least partially resides inside the splashguard 150 or the splashguard 150 at least partially resides inside the output port 130. Further, the splashguard 150 may be attached to the output port 130 and/or the

lid 114. For example the splashguard 150 may be welded, adhered, or otherwise secured to the output port 130 and/or the lid 114. Additionally, or alternatively, the splashguard 150 and the output port 130 may include complimentary threaded portions, such that one of the splashguard 150 and the output port 130 may be threaded into the other.

[0034] As illustrated in Figure 6, the splashguard 150 may attached to the output port 130 at an angle 610 with the lid 114. For example, the angle 610 may be in a range of about 2 degrees to about 10 degrees. In one particular example, the angle is about 5 degrees. Further, the angle may be in a range of about 2 degrees to about 10 degrees.

[0035] The splashguard 150 may include one or more openings. For example, the splashguard 150 may include opening 152 and opening 154. Alternatively, the splashguard 150 may include opening 152 and omit opening 154.

[0036] As is stated above, by utilizing the diffuser 140 having a ring shaped nozzle (e.g., 144) with a plurality of holes 146 and the splashguard 150, splashes affecting an output of the ampoule may be reduced. The holes 146 may be configured to increase the efficiency of a carrier gas flowing through, reducing splashes within the ampoule. Further, the splashguard 150 may be configured to prevent liquid from entering the output port 130, interfering with the flow a vaporized precursor through the output port 130. Thus, the efficiency of the ampoule 100 may be increased.

[0037] While the foregoing is directed to embodiments described herein, other and further embodiments may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

What is claimed is:

1. An ampoule comprising:
a container comprising a bottom, a sidewall and a lid enclosing a cavity;
an inlet port;
an output port;
a diffuser disposed within the cavity, the diffuser comprising:
a feed tube coupled to the inlet port; and
a nozzle coupled to the feed tube, the nozzle having a closed ring shape and comprising a plurality of holes, wherein a centerline of each of the plurality of holes is oriented to direct fluid away from the lid; and
a splashguard coupled to the output port.

2. The ampoule of claim 1, wherein a diameter of at least two of the plurality of holes is the same.

3. The ampoule of claim 2, wherein one of the plurality of holes has a diameter between about 10 mm to about 40 mm.

4. The ampoule of claim 1, wherein the nozzle further comprises a top portion, a bottom portion an interior portion and an exterior portion, wherein the plurality of holes are disposed on the bottom portion, the interior portion and the exterior portion, and not on the top portion.

5. The ampoule of claim 1, wherein an inner diameter of the nozzle is greater than an inner diameter of the feed tube.

6. The ampoule of claim 1, wherein the nozzle is disposed proximate to the bottom of the container.

7. The ampoule of claim 1, where the splashguard comprises a first opening that is oriented between about 3 degrees to about 10 degrees with reference to the lid of the container.

8. An ampoule comprising:
a container comprising a bottom, a sidewall and a lid enclosing a cavity;
an inlet port;
an output port;
a diffuser disposed within the cavity, the diffuser comprising:
a feed tube coupled to the inlet port; and
a nozzle coupled to the feed tube, the nozzle having a closed ring shape and comprising a plurality of holes, wherein an inner diameter of the nozzle is greater than an inner diameter of the feed tube; and
a splashguard coupled to the output port.

9. The ampoule of claim 8, wherein a centerline of each of the plurality of holes is oriented to direct fluid away from the lid.

10. The ampoule of claim 8, wherein at least two of the plurality of holes have the same diameter.

11. The ampoule of claim 8, wherein nozzle is disposed proximate the bottom of the container.

12. The ampoule of claim 8, where the splashguard comprises a first opening that is oriented between about 3 degrees to about 10 degrees with reference to the lid of the container.

13. An ampoule comprising:
a container comprising a bottom, a sidewall and a lid enclosing a cavity;
an inlet port;

an output port;

a diffuser coupled to the inlet port and disposed within the cavity, the diffuser comprises:

a feed tube coupled to the inlet port; and

a nozzle coupled to the feed tube, the nozzle comprising a plurality of holes, wherein a cross-section area of the plurality of holes is larger than an inner diameter of the feed tube; and

a splashguard coupled to the output port.

14. The ampoule of claim 13, wherein the nozzle has an inner diameter greater than an inner diameter of the feed tube.

15. The ampoule of claim 13, wherein the nozzle has a closed ring shape, and wherein a centerline of each of the plurality of holes is oriented to direct fluid away from the lid.

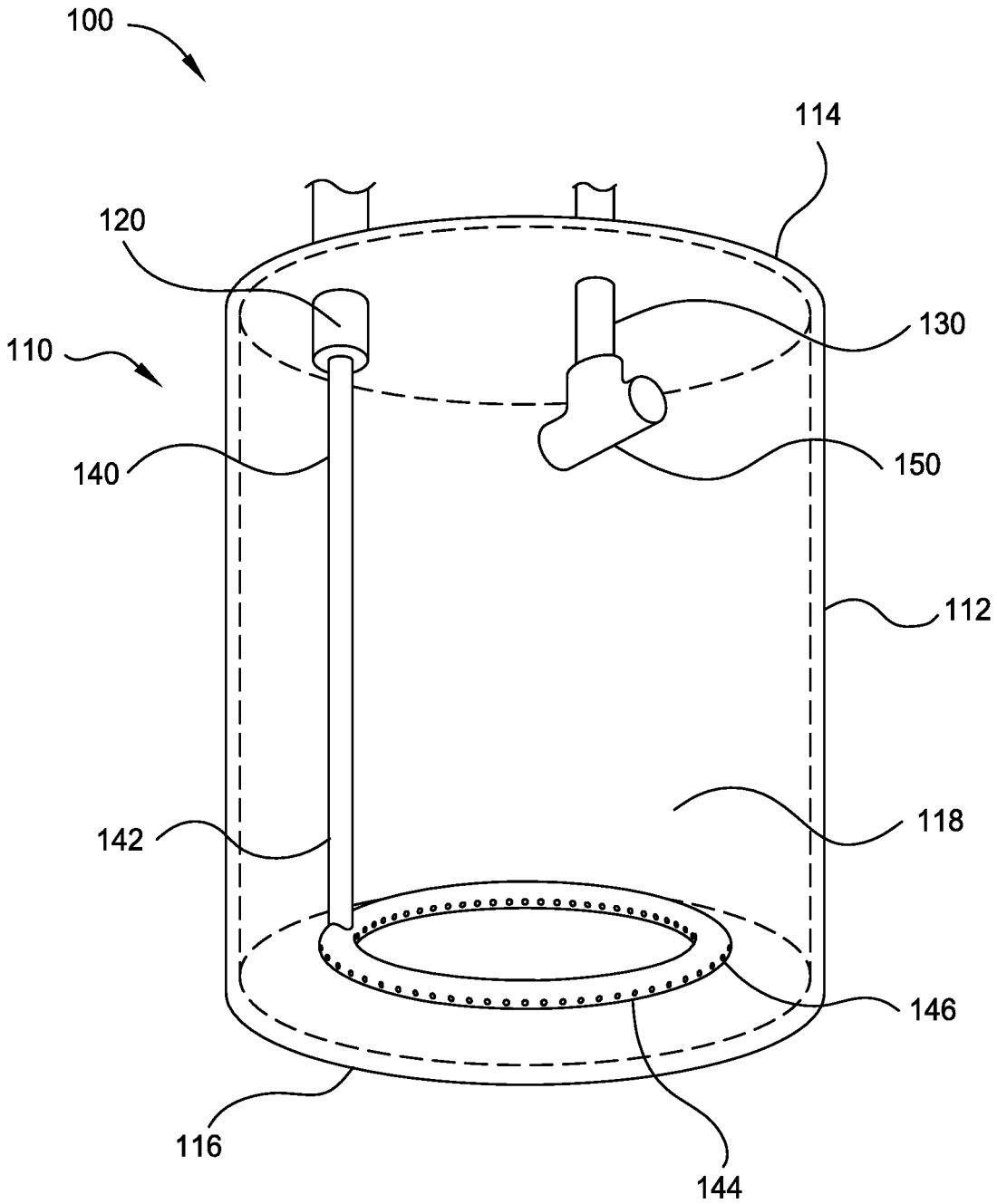


FIG. 1

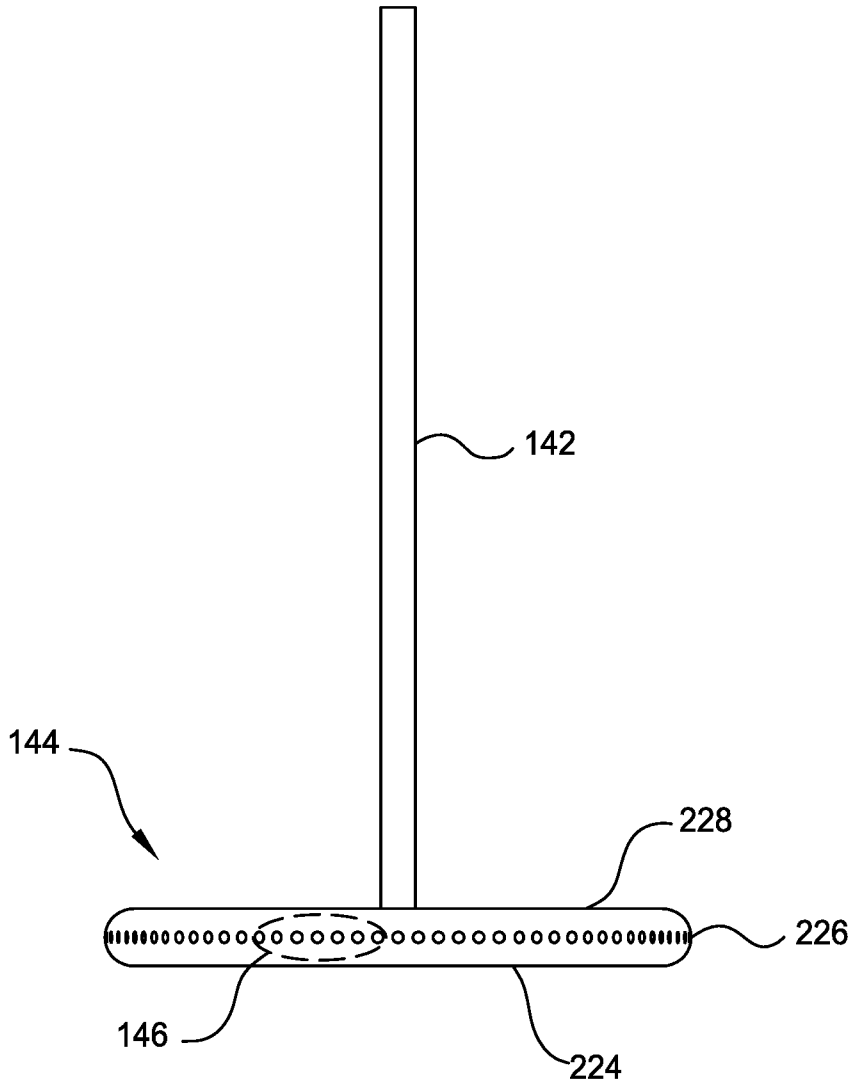


FIG. 2

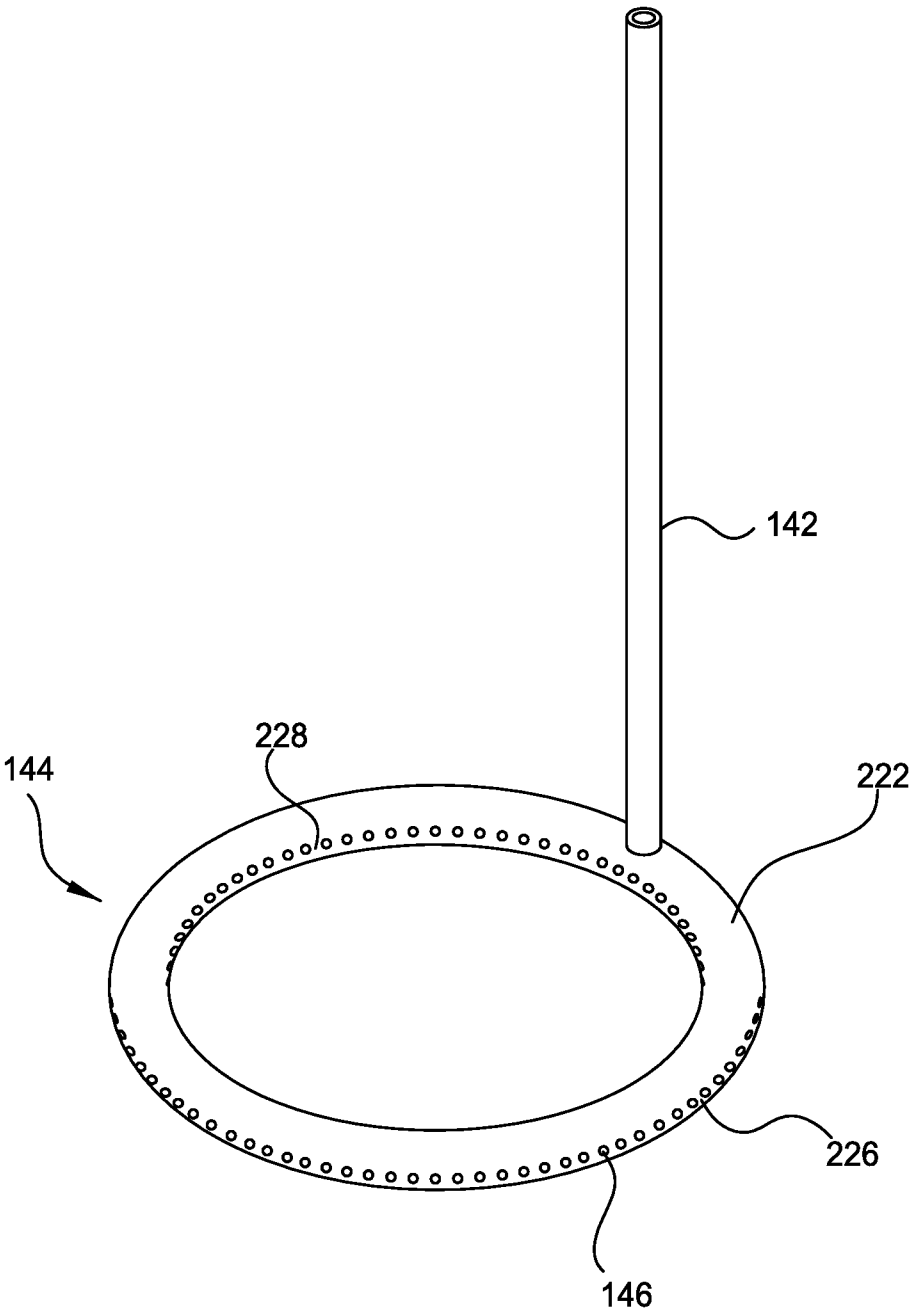


FIG. 3

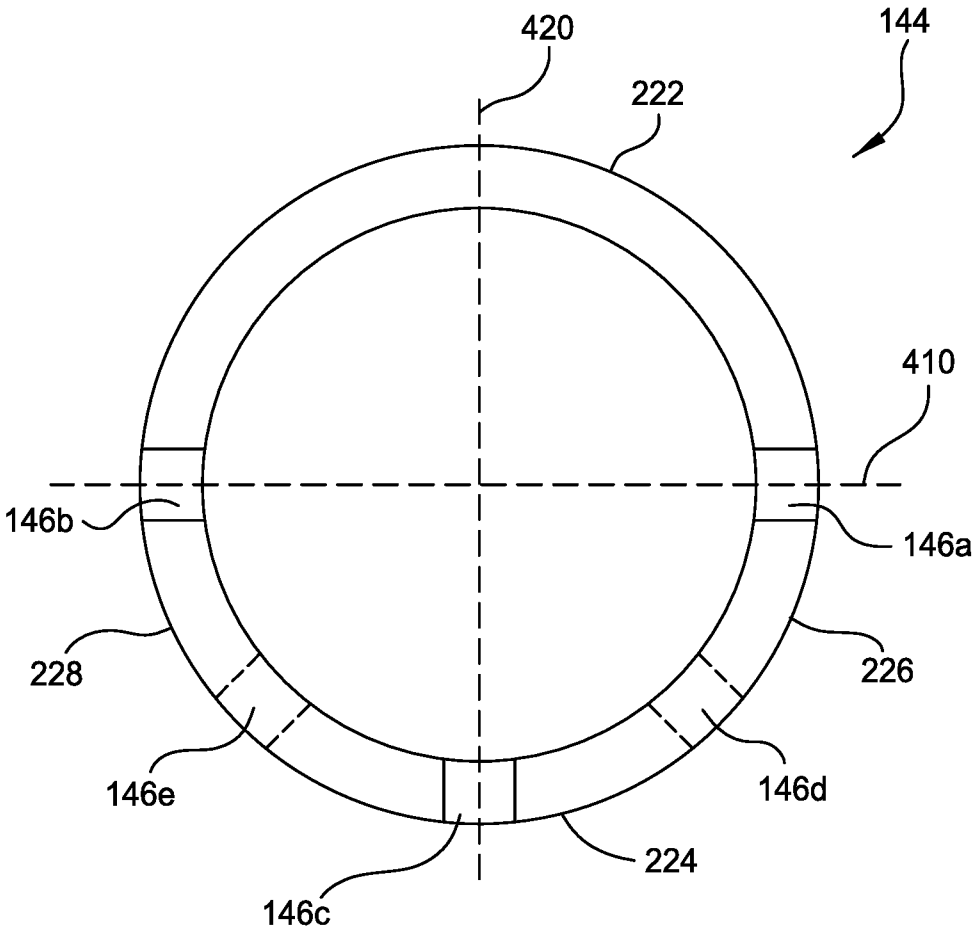


FIG. 4

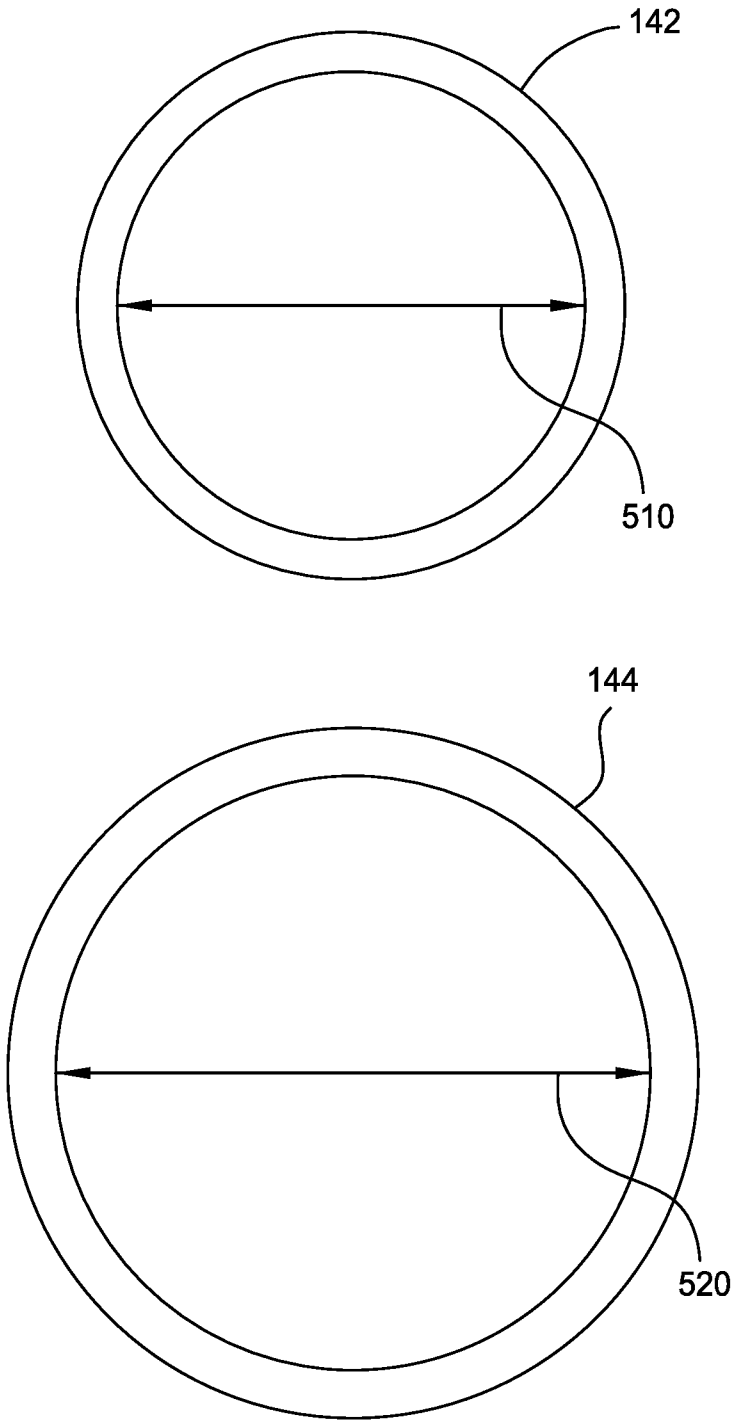


FIG. 5

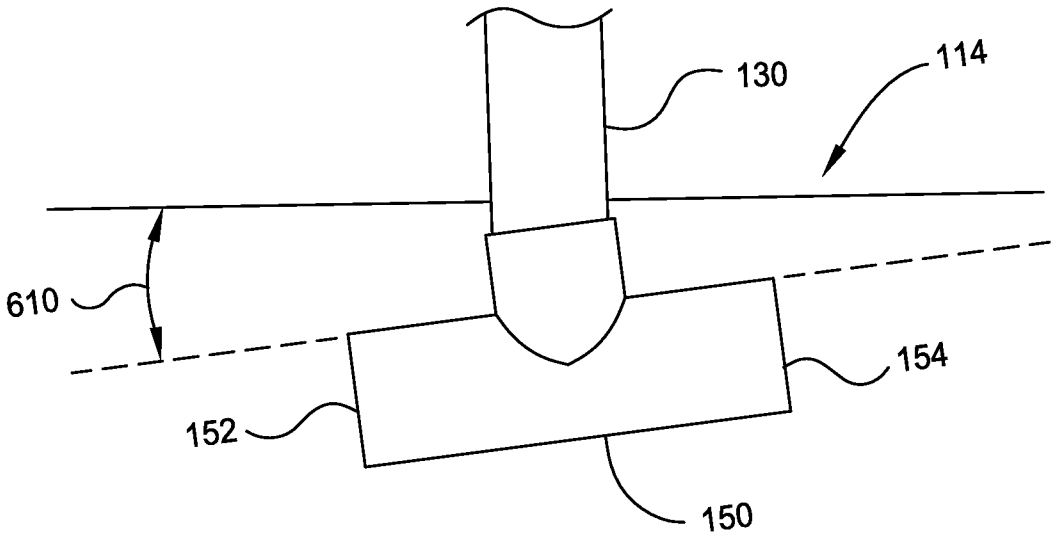


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/065049

A. CLASSIFICATION OF SUBJECT MATTER

C23C 16/448(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C23C 16/448; B01F 3/04; B01J 19/00; C07C 5/09; C07D 301/02; C23C 16/44; C23C 16/54

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: ampoule, container, diffuser, feed tube, nozzle, splashguard

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2010-0112215 A1 (CUVALCI et al.) 06 May 2010 See paragraphs [0022]-[0028]; and figures 1A-1C.	1-15
Y	US 2010-0174099 A1 (BEHKISH et al.) 08 July 2010 See paragraphs [0036]-[0044]; and figures 1, 1A, 2.	1-15
A	US 2014-0114102 A1 (GUANGDONG XINHUAYUE HUADE TECHNOLOGY CO., LTD.) 24 April 2014 See paragraphs [0037]-[0038]; and figures 1-3.	1-15
A	US 4961882 A (BHAGAT et al.) 09 October 1990 See column 2, line 46 - column 3, line 65; and figures 1-4.	1-15
A	EP 0420596 A1 (CANON KABUSHIKI KAISHA) 03 April 1991 See page 5, line 15 - page 6, line 6; and figures 1-3.	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 August 2019 (23.08.2019)	**23 August 2019 (23.08.2019)**

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KIM, Jin Ho
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2018/065049

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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