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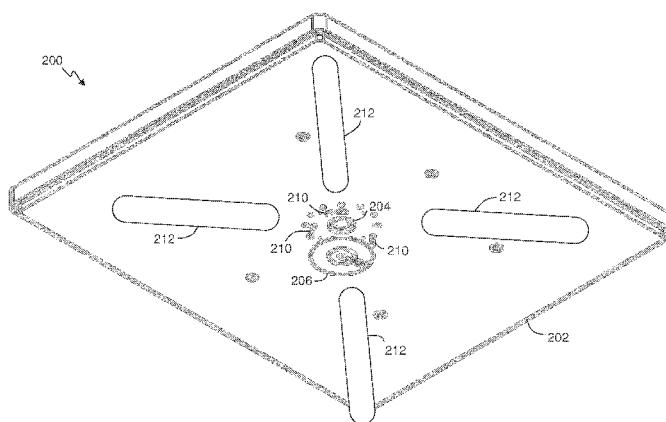


FIG. 2A

(57) **Abstract:** The present invention provides methods and apparatus for a gas diffusion assembly in a deposition processing chamber. The invention includes a backing plate having an inlet for providing a process gas to a process chamber, a diffusion plate including a plurality of apertures for allowing the process gas to flow into the process chamber, a blocking plate disposed between the backing plate and the diffusion plate and including a plurality of apertures, and at least one gas flow guide disposed between the blocking plate and the backing plate and adapted to direct process gas flow laterally. Numerous additional features are disclosed.

**PROCESS GAS FLOW GUIDES FOR LARGE AREA PLASMA ENHANCED
CHEMICAL VAPOR DEPOSITION SYSTEMS AND METHODS**

5 **RELATED APPLICATIONS**

The present application claims priority from U.S. Provisional Patent Application Serial No. 61/675,791, filed July 25, 2012, entitled "PROCESS GAS FLOW GUIDES FOR LARGE AREA PLASMA ENHANCED CHEMICAL VAPOR DEPOSITION
10 SYSTEMS AND METHODS" (Attorney Docket No. 17243/DSS/AHRDWR/E SONG) which is hereby incorporated herein by reference in its entirety for all purposes.

15 **FIELD**

The present invention generally relates to electronic device manufacturing, and more particularly is directed to process gas flow guides for large area plasma-enhanced chemical vapor deposition systems and methods.

20

BACKGROUND

One of the primary steps in the fabrication of modern electronic devices is the formation of a thin layer on a
25 substrate by chemical reaction of gases. Such a deposition process is referred to generally as chemical-vapor deposition ("CVD"). Conventional thermal CVD processes supply reactive gases to the substrate surface

where heat-induced chemical reactions take place to produce a desired layer. Plasma-enhanced CVD ("PECVD") techniques, on the other hand, promote excitation and/or dissociation of the reactant gases by the application of radio-frequency ("RF") energy to a reaction zone near the substrate surface, thereby creating a plasma. The high reactivity of the species in the plasma reduces the energy required for a chemical reaction to take place, and thus lowers the temperature required for such CVD processes as compared to conventional thermal CVD processes.

Low-Temperature Polysilicon processes, such as those used in the fabrication of flat panel display screens, are carried out in process chambers which typically include a gas distribution assembly through which gases are introduced into the process chamber. Gas distribution assemblies are commonly utilized in PECVD chambers to uniformly distribute gases over the substrate surface upon their introduction into the chamber. In general, uniform gas distribution over the substrate enhances uniform deposition characteristics on the surface of the substrate positioned in the chamber for processing.

Generally, a gas distribution assembly includes a grounded gas inlet manifold connected to a gas source to provide gases to a process chamber. The gas inlet manifold allows gases to flow into a gas diffuser to uniformly introduce gases into the PECVD chamber above a substrate surface. Referring to the prior art PECVD chamber 10 depicted in FIG. 1, a gas diffuser system 100

communicates directly with the PECVD chamber 10 and typically includes a backing plate 102 with a gas inlet 104, a blocker plate 106, and a diffuser plate 108 to evenly disperse gases from a single gas feed line over at least the area of the substrate while minimizing turbulent gas flow. The blocker plate 104 is generally a flat, annular plate member having a plurality of very small apertures passing therethrough to disperse the gas from the inlet 104 uniformly into a space 110 above the diffuser plate 108. The gas is typically provided via a single gas line wherein the reactant and carrier gases have been mixed, thereby providing a high concentration of gas over the center of the blocker plate 106 at a localized area. The diffuser plate 108 is also a generally flat, annular member having a plurality of apertures, larger than the apertures of the blocker plate 106, through which the gases pass or diffuse to provide a uniform concentration of gases evenly over the substrate.

Despite the arrangement described above, the inventors of the present invention have noticed that in some circumstances, the deposition rates over the area of a substrate that result from the prior art gas diffuser system 100 are not uniform. Thus, methods and apparatus that enable more uniform deposition rates over the area of a substrate are needed.

SUMMARY

Inventive methods and apparatus are provided for a gas diffusion assembly in a deposition processing chamber. The assembly includes a backing plate having an inlet for providing a process gas to a process chamber, a diffusion plate including a plurality of apertures for allowing the process gas to flow into the process chamber, a blocking plate disposed between the backing plate and the diffusion plate and including a plurality of apertures, and at least one gas flow guide disposed between the blocking plate and the backing plate and adapted to direct process gas flow laterally.

In some embodiments, the invention provides a low-temperature polysilicon processing chamber system. The system includes a process gas supply, a susceptor for supporting a substrate, and a gas diffusion assembly. The gas diffusion assembly includes a backing plate having an inlet coupled to the process gas supply, a diffusion plate including a plurality of apertures for allowing the process gas to flow to the substrate, a blocking plate disposed between the backing plate and the diffusion plate and including a plurality of apertures, and at least one gas flow guide disposed between the blocking plate and the backing plate and adapted to direct process gas flow laterally.

In yet other embodiments, the invention provides a method of flowing process gas into a processing chamber. The method includes determining an area on a substrate

that will otherwise receive a relatively low deposition rate, and directing process gas to flow laterally between a backing plate and a diffusion plate to an area above the substrate that will otherwise receive a relatively low deposition rate on the substrate.

Numerous other aspects are provided. Other features and aspects of the present invention will become more fully apparent from the following detailed description, the appended claims and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic drawing depicting an example of a prior art plasma enhanced chemical vapor deposition chamber.

5 FIG. 2A is an upward-looking, exploded perspective view of an example of a gas diffuser assembly (with the diffuser plate removed for clarity) according to some embodiments of the present invention.

10 FIG. 2B is an upward-looking, plan view of an example of a gas diffuser assembly (with the diffuser plate removed for clarity) according to some embodiments of the present invention.

15 FIG. 3 is cross-sectional view of an example gas diffuser assembly according to some embodiments of the present invention.

FIG. 4 is a magnified, cross-sectional view of the encircled portion M of the example gas diffuser assembly of FIG. 3 according to some embodiments of the present invention.

20 FIG. 5A is a simplified, cross-sectional view of a portion of an example gas diffuser assembly according to some embodiments of the present invention.

25 FIG. 5B is a simplified, cross-sectional view of a portion of an alternative example gas diffuser assembly according to some embodiments of the present invention.

FIG. 6 is a perspective view of an example of inner flow guides disposed around a gas inlet (with the blocker

and diffuser plates removed for clarity) according to some embodiments of the present invention.

FIG. 7 is a graph depicting relative deposition rates over the area of a substrate resulting from using a
5 conventional gas diffuser assembly of the prior art.

FIG. 8 is a graph depicting relative deposition rates over the area of a substrate achieved with the use of the gas diffuser assembly of the present invention.

FIG. 9 is a flowchart depicting an example method of
10 flowing gas through a gas diffuser assembly according to some embodiments of the present invention.

DETAILED DESCRIPTION

The present invention provides improved methods and apparatus for achieving uniform deposition rates during chemical vapor deposition. In particular, the present invention is helpful in achieving more uniform deposition when manufacturing large area (e.g., greater than 730mm x 920mm substrates), Low-Temperature Polysilicon (LTPS) displays. However, the invention is applicable to other processes, sizes, and configurations.

LTPS Liquid Crystal Display (LCD) PECVD technology enables the manufacturing of active matrix display screens that are faster and more integrated than screens made with amorphous silicon. Rather than the single-crystal silicon used in chips, amorphous silicon advanced the active matrix industry by allowing thin film transistors (TFTs) to be deposited on large substrates. Despite the large investment in existing amorphous technology, polysilicon provides an alternate approach for certain applications. The larger and more uniform grains of polysilicon (poly-Si) allow electrons to flow 100 times faster than through the random-sized grains of amorphous silicon (a-Si), enabling higher resolutions and higher speed. In addition, instead of surrounding the screen area, the row/column driver electronics are integrated onto the glass substrate, thereby reducing the TFT section and the wiring between the pixels. Thus, LTPS pixels can be closer together and achieve densities of 200 dpi and greater.

There are several important types of SiO_x layers used in LTPS process. Three of these layer types include gate insulator (GI) layer, interlayer dielectric (ILD) layer, and amorphous precursor buffer layer. The thickness
5 uniformity of these SiO_x layers, in particular GI SiO_x, may be very critical for successful LTPS manufacturing. The SiO_x film thickness uniformity and properties have been found to be prominently dependent on the process gas flow distribution. Thus, creating a uniform process gas
10 flow over large area substrates is important for uniform SiO_x film deposition.

Existing systems for LTPS gas distribution rely on a gas blocker or deflector plate. The blocker plate has been effective to improve SiO_x uniformity locally at the
15 center of the substrate area. However, existing blocker plates distribute gases evenly in all lateral directions. The present inventors have noticed that even lateral distribution does not address the non-uniformities caused by other factors affecting film thickness. Many of these
20 factors, including electrode distance (e.g., distance between diffuser and susceptor), plasma density, gas flow velocity, and the like, are not easily adjusted due to other film layer requirements or other unalterable physical characteristics. As a result, the present
25 inventors have noticed a pattern of high and low deposition rates in certain areas when a blocking plate provides an even lateral distribution of gas. In particular, the pattern includes a high deposition rate

along two crossing diagonal lines extending from corner to corner of the substrate. Further, the pattern includes areas of low deposition rates proximate to the center of relatively long (e.g., approximately 2500 mm) edges of the substrate. This particular pattern has been labeled a "butterfly pattern" and the occurrence of this deposition pattern can be a limiting factor for SiO_x thickness uniformity which critically affects LTPS processes.

The present invention overcomes the problem of the butterfly pattern by controlling the lateral flow of the process gas between the backing plate and the diffusion plate. Instead of evenly distributing the process gas laterally as in the prior art, the gas diffuser assembly of the present invention provides gas flow guides that affect the lateral flow of gas from the gas inlet over the diffusion plate. In particular, inner gas flow guides are used to direct more gas to the areas over the substrate that have lower deposition rates and outer gas flow guides are used to reduce the vertical space available for gas to flow over the areas on the substrate that have higher gas flow deposition rates. In other words, by engineering a lateral gas flow pattern between the backing plate and the diffuser plate that inversely matches the deposition rate pattern that would otherwise result from even lateral gas flow distribution between the backing plate and the diffuser plate, the present invention provides a gas diffuser assembly that achieves an improved uniformity of deposition rate over the area of the substrate.

More specifically, to reduce the higher deposition rate along center-crossing diagonal lines and the lower deposition rate along the center of long edges, four inner gas flow guides are disposed between the blocking plate and the backing plate so as to form openings for lateral gas flow towards the center of long edges of the substrate. In some embodiments, arrangements with five or more, or three or less inner gas flow guides may be used. The openings that face the area over the long edges of the substrate are larger (e.g., two times larger) than the openings that face the area over the shorter edges of the substrate. These inner gas flow guides also create barriers against lateral gas flow towards the corners of the substrate. In addition, outer gas flow guides which reduce the vertical space between the backing plate and the diffuser plate are disposed to reduce the amount of gas that flows over the center-crossing diagonal lines. In some embodiments, four outer gas flow guides are used, disposed in a radial pattern. In other embodiments, arrangements with five or more, or three or less, outer gas flow guides may be used. In some embodiments, the outer gas flow guides may be shaped to match the shape of the relatively higher deposition areas that occur without the guides in place. In other words, the panels used to reduce the vertical space between the backing plate and the diffuser plate can be shaped to match or correspond to the non-uniformities (e.g., high spots or deposition peaks) witnessed in a conventional chamber.

Turning now to FIG. 2A, an upward-looking, exploded perspective view of an example of a gas diffuser assembly 200 of the present invention is provided. The diffuser plate is not shown so that the other components can be
5 seen. The gas diffuser assembly 200 includes a rectangular-shaped backing plate 202 having an inlet 204 formed therein. In some embodiments, the backing plate 202 may serve as a removable lid or top plate for the processing chamber. Note that the gas diffuser assembly
10 200 of the present invention is adapted to be a direct replacement of the gas diffuser assembly 100 of the prior art chamber 10. Thus, addition of the gas diffuser assembly 200 of the present invention to an existing chamber 10 (in place of a conventional gas diffuser
15 assembly 100), represents a new chamber according to the present invention. The inlet 204 is covered by a disk-shaped deflector or blocking plate 206 that includes a radial arrangement of apertures adapted to allow gas from the inlet 204 to flow to the chamber. In FIG. 2A, only a
20 small number of the apertures are represented in the blocking plate 206.

In some embodiments of the invention as shown in FIG. 2A, inner gas flow guides 210 are disposed around the inlet 204 between the backing plate 202 and the blocking
25 plate 206. The inner gas flow guides 204 are solid, curved bars that can be located at any desired location between the backing plate 202 and the blocking plate 206 to prevent lateral gas flow in some directions and to

allow lateral gas flow in other directions. The height of the inner gas flow guides 204 determines the distance between the backing plate 202 and the blocking plate 206. This distance has been found to affect the deposition rate
5 in the center area of the substrate and thus, the height of the inner gas flow guides 204 is carefully selected to avoid a local deposition peak or valley in the center of the substrate.

In the particular example embodiment shown, four
10 inner gas flow guides 210 (only three are visible due to the blocking plate 206) are arranged around the periphery of the blocking plate 206 but set back from the edge of the blocking plate 206. Other set back distances may be used. The inner gas flow guides 210 are positioned so as
15 to form two larger lateral openings facing the area above where the center of the longer edges of a substrate would be located and two smaller openings facing the area above where the center of the shorter edges of a substrate would be located. Thus, the position of the inner flow guides
20 210 are adapted (1) to block lateral gas flow from the area above corners of the substrate; (2) to allow some lateral gas flow toward the area above where the center of the shorter edges of the substrate; and (3) to allow more lateral gas flow toward the area above where the center of
25 the longer edges of the substrate. Other configurations for different processes can be used.

In some embodiments, the inner gas flow guides 210 may be formed from aluminum or any other practicable

material. The inner gas flow guides 210 may be adapted to be securely fastened to the backing plate 202. Likewise, the blocking plate 206 may be adapted to be securely fastened to the inner gas flow guides 210. More details
5 regarding the inner gas flow guides 210 are provided below with respect to FIGs. 5A, 5B, and 6.

The gas diffuser assembly 200 of the present invention may also include outer gas flow guides 212. The outer gas flow guides 212 may be embodied as elongated
10 rectangular or oval-shaped spacers extending radially from the inlet 204 toward the corners of the backing plate 202. In some embodiments, other shapes may be used. The outer gas flow guides 212 may be securely attached to the backing plate 202 and function to reduce the vertical area
15 between the backing plate 202 and the diffuser plate. Any practicable shape may be used depending on the process or other factors. In some embodiments, the shape of the outer gas flow guides 212 may be selected to match the deposition rate (e.g., thickness) pattern that would
20 otherwise form on the substrate without the outer gas flow guides 212. In some embodiments, the outer gas flow guides 212 may be embodied as flat aluminum plates and may include square, rounded, or beveled edges.

In an alternative embodiments of the gas diffuser assembly 200', the outer gas flow guides 212 may have
25 different shapes and/or varying thicknesses that correspond or are related to the deposition rate pattern that would otherwise result without the presence of the

outer gas flow guides 212 during processing. For example, as depicted in FIG. 2B, the outer gas flow guides 212' can have a teardrop or pear shape to better match the deposition pattern that would otherwise result without the presence of the outer gas flow guides.

FIGs. 3 and 4 depict a cross-sectional view of an example gas diffuser assembly 200 of the present invention. Note that FIG. 4 is a magnified view of the encircled portion M of the gas diffuser assembly 200 of FIG. 3. Specifically, these drawings illustrate a cross-sectional view showing the inner flow guides 210 disposed around the inlet 204 between the backing plate 202 and the blocking plate 206. The diffuser plate 308 is shown below the blocking plate 206. Note that the apertures in the diffuser plate 308 and in the blocking plate 206 are not represented. Also, note that the outer gas flow guides 212 are not represented in these cross-sectional drawings.

Turning now to FIG. 5A, a simplified, schematic cross-sectional view of a portion of an example gas diffuser assembly 200 is provided. This particular view is provided to illustrate some of the dimensions that may be adjusted to achieve the desired lateral gas flow which results in a more uniform deposition rate over the area of the substrate. Specifically, dimension A is the vertical height of the space between the backing plate 202 and the diffuser plate 308, dimension B is the vertical height of the space between the blocker plate 206 and the diffuser plate 308, and dimension C is the vertical height of the

space between the outer gas flow guides 212 and the diffuser plate 308. Thus, as can be seen in FIG. 5A, the height of the inner gas flow guides 210 allow adjustment of dimension B and the thickness of the outer gas flow guides 212 allow adjustment of dimension C.

Turning now to FIG. 5B, a simplified, schematic cross-sectional view of a portion of an alternative example gas diffuser assembly 200' is provided. As above, this view illustrates some of the dimensions that may be adjusted to achieve the desired lateral gas flow which results in a more uniform deposition rate over the area of the substrate. Specifically, dimension A is the vertical height of the space between the backing plate 202 and the diffuser plate 308, dimension B is the vertical height of the space between the blocker plate 206 and the diffuser plate 308, dimension C' is the minimum vertical height of the space between the outer gas flow guides 212' and the diffuser plate 308, and dimension C'' is the maximum vertical height of the space between the outer gas flow guides 212' and the diffuser plate 308. Thus, as can be seen in FIG. 5B, the height of the inner gas flow guides 210 allow adjustment of dimension B and the shape of the outer gas flow guides 212' allow adjustment of dimensions C' and C''.

FIG. 6 provides an enlarged and inverted perspective view of an example of the four inner flow guides 210 disposed around the gas inlet 204 and mounted to the

backing plate 202. The blocker and diffuser plates are not shown.

As described above, the inner gas flow guides 210 are positioned so as to form two larger lateral openings

5 (labeled with dimension D) facing the area above where the center of the longer edges of a substrate would be located and two smaller openings (labeled with dimension E) facing the area above where the center of the shorter edges of a substrate would be located. Thus, as also explained
10 above, the position of the inner flow guides 210 are adapted (1) to block lateral gas flow from the area above corners of the substrate; (2) to allow some lateral gas flow toward the area above where the center of the shorter edges of the substrate; and (3) to allow more lateral gas
15 flow toward the area above where the center of the longer edges of the substrate.

FIGS. 7 and 8 show thickness maps 700, 800 of film deposition using a chamber commercially available from Applied Materials, Santa Clara, CA, with and without the
20 diffuser assembly of the present invention.

More specifically, FIG. 7 is a thickness graph 700 depicting relative deposition rates over the area of a relatively large substrate resulting from using a conventional gas diffuser assembly of the prior art. The
25 resulting butterfly pattern includes areas of low deposition rates 702 proximate to the center of relatively long (e.g., approximately 2500 mm) edges of the substrate and a high deposition rate area 704 along two crossing

diagonal lines extending from corner to corner of the substrate. This level of film thickness non-uniformity is problematic.

FIG. 8 is a thickness graph 800 depicting relative
5 deposition rates over the area of a substrate achieved with the use of the gas diffuser assembly of the present invention. According to the present invention, gas is distributed laterally between the baking plate and the diffuser plate using inner and outer gas flow guides.

10 Compared with the thickness variation using the prior art gas diffuser assembly as determined in FIG. 7, the gas diffuser assembly of the present invention achieved a reduction in thickness variation which represents an improvement in uniformity.

15 FIG. 9 is a flowchart depicting an example method 900 of flowing gas through a gas diffuser assembly according to some embodiments of the present invention. In operation, areas of relatively low deposition rate on a test substrate are determined (902). In some embodiments,
20 areas of relatively high deposition rate on the test substrate are also determined (904). Based on the determinations of the high and low deposition rates, inner flow guides are disposed around the gas inlet between the backing plate and the blocking plate to direct process gas
25 laterally toward areas over substrate areas that had a relatively low distribution rate on the test substrate (906). In some embodiments, the inner guides may additionally be disposed to block process gas from flowing

laterally toward areas over substrate areas that had a relatively high deposition rate on the test substrate. Additionally, outer flow guides are disposed over substrate areas that had a relatively high deposition rate
5 on the test substrate (908).

Accordingly, while the present invention has been disclosed in connection with the preferred embodiments thereof, it should be understood that other embodiments may fall within the spirit and scope of the invention, as
10 defined by the following claims.

The invention claimed is:

1. A gas diffusion assembly comprising:
 - a backing plate having an inlet for providing a process gas to a process chamber;
 - a diffusion plate including a plurality of apertures for allowing the process gas to flow into the process chamber;
 - a blocking plate disposed between the backing plate and the diffusion plate and including a plurality of apertures; and
 - at least one gas flow guide disposed between the blocking plate and the backing plate and adapted to direct process gas flow laterally.
2. The gas diffusion assembly of claim 1 wherein the at least one gas flow guide is adapted to direct process gas flow laterally toward an area above a substrate that would otherwise receive a lower deposition rate.
3. The gas diffusion assembly of claim 1 wherein the at least one gas flow guide is adapted to direct process gas flow laterally away from an area above a substrate that would otherwise receive a higher deposition rate.
4. The gas diffusion assembly of claim 1 wherein the at least one gas flow guide includes four inner gas flow guides disposed around the inlet.

5. The gas diffusion assembly of claim 4 wherein the inner gas flow guides are adapted to direct SiO_x process gas laterally toward an area above a long edge of a substrate.

6. The gas diffusion assembly of claim 4 wherein the inner gas flow guides are adapted to direct SiO_x process gas laterally away from an area above a corner of a substrate.

7. The gas diffusion assembly of claim 1 wherein the at least one gas flow guide is adapted to restrict lateral process gas flow from an area above a substrate that would otherwise receive a higher deposition rate.

8. The gas diffusion assembly of claim 1 wherein the at least one gas flow guide includes four outer gas flow guides disposed around the inlet.

9. The gas diffusion assembly of claim 8 wherein the four outer gas flow guides are adapted to restrict lateral flow of SiO_x process gas from an area above center-crossing diagonal lines on a substrate.

10. A low-temperature polysilicon processing chamber system comprising:

a process gas supply;

a susceptor for supporting a substrate; and
a gas diffusion assembly including:

a backing plate having an inlet coupled to the
process gas supply;

a diffusion plate including a plurality of
apertures for allowing the process gas to flow to the
substrate;

a blocking plate disposed between the backing
plate and the diffusion plate and including a
plurality of apertures; and

at least one gas flow guide disposed between the
blocking plate and the backing plate and adapted to
direct process gas flow laterally.

11. The low-temperature polysilicon processing chamber system of claim 10 wherein the at least one gas flow guide is adapted to direct process gas flow laterally toward an area above the substrate that would otherwise receive a lower deposition rate.

12. The low-temperature polysilicon processing chamber system of claim 10 wherein the at least one gas flow guide is adapted to direct process gas flow laterally away from an area above the substrate that would otherwise receive a higher deposition rate.

13. The low-temperature polysilicon processing chamber system of claim 10 wherein the at least one gas flow guide

includes four inner gas flow guides disposed around the inlet.

14. The low-temperature polysilicon processing chamber
5 system of claim 13 wherein the inner gas flow guides are adapted to direct SiO_x process gas laterally toward an area above a long edge of a substrate.

15. The low-temperature polysilicon processing chamber
10 system of claim 13 wherein the inner gas flow guides are adapted to direct SiO_x process gas laterally away from an area above a corner of the substrate.

16. The low-temperature polysilicon processing chamber
15 system of claim 10 wherein the at least one gas flow guide is adapted to restrict lateral process gas flow from an area above the substrate that would otherwise receive a higher deposition rate.

20 17. The low-temperature polysilicon processing chamber system of claim 10 wherein the at least one gas flow guide includes four outer gas flow guides disposed around the inlet.

25 18. The low-temperature polysilicon processing chamber system of claim 17 wherein the four outer gas flow guides are adapted to restrict lateral flow of SiO_x process gas

from an area above center-crossing diagonal lines on the substrate.

19. A method of flowing process gas into a processing
5 chamber, the method comprising:

determining an area on a substrate that will
otherwise receive a relatively low deposition rate; and

directing process gas to flow laterally between a
backing plate and a diffusion plate to an area above the
10 substrate that will otherwise receive a relatively low
deposition rate on the substrate.

20. The method of claim 19 further comprising:

determining an area on a substrate that will
15 otherwise receive a relatively high deposition rate; and

directing process gas to flow laterally between the
backing plate and the diffusion plate away from an area
above the substrate that will otherwise receive a
relatively high deposition rate on the substrate.

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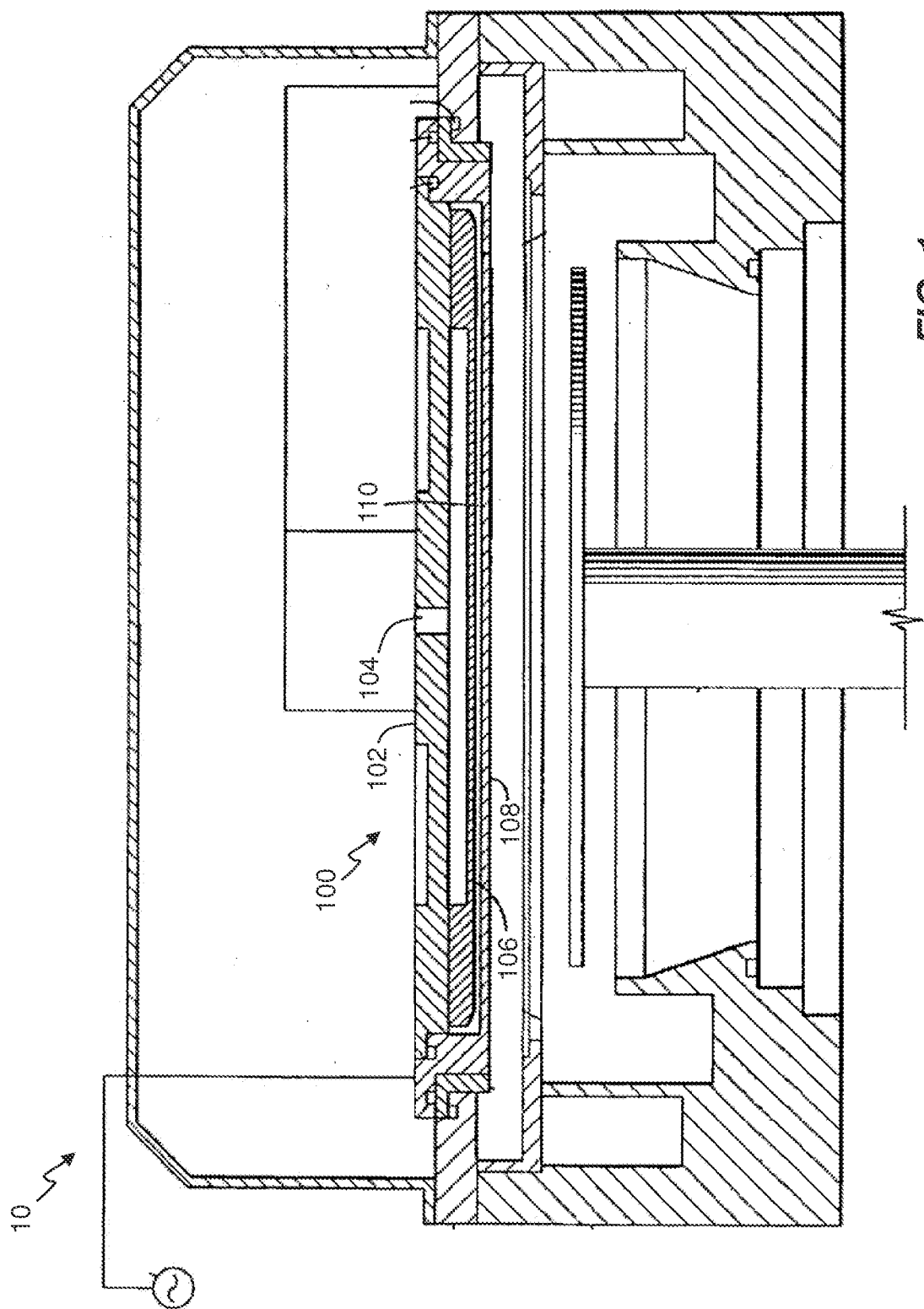


FIG. 1
(PRIOR ART)

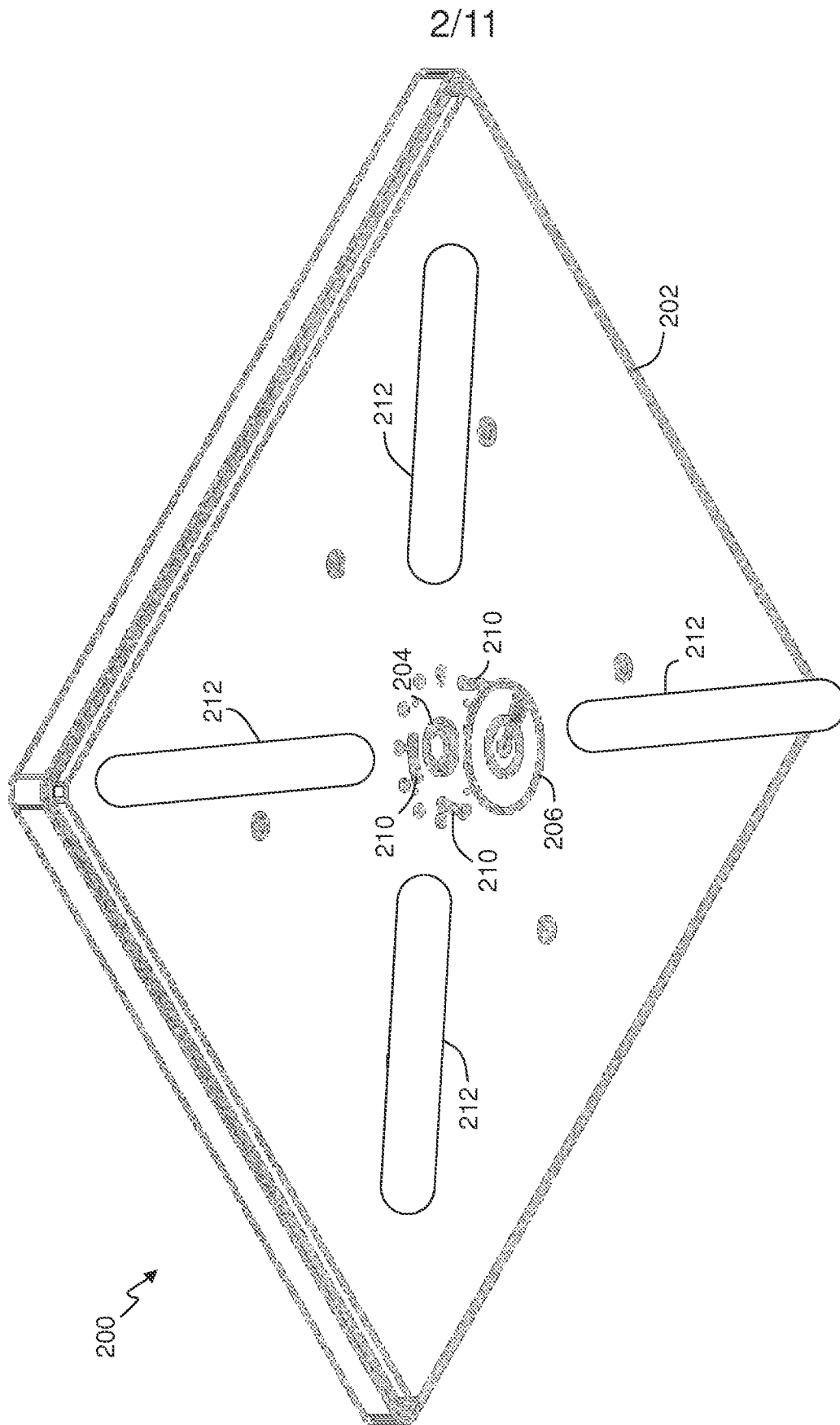


FIG. 2A

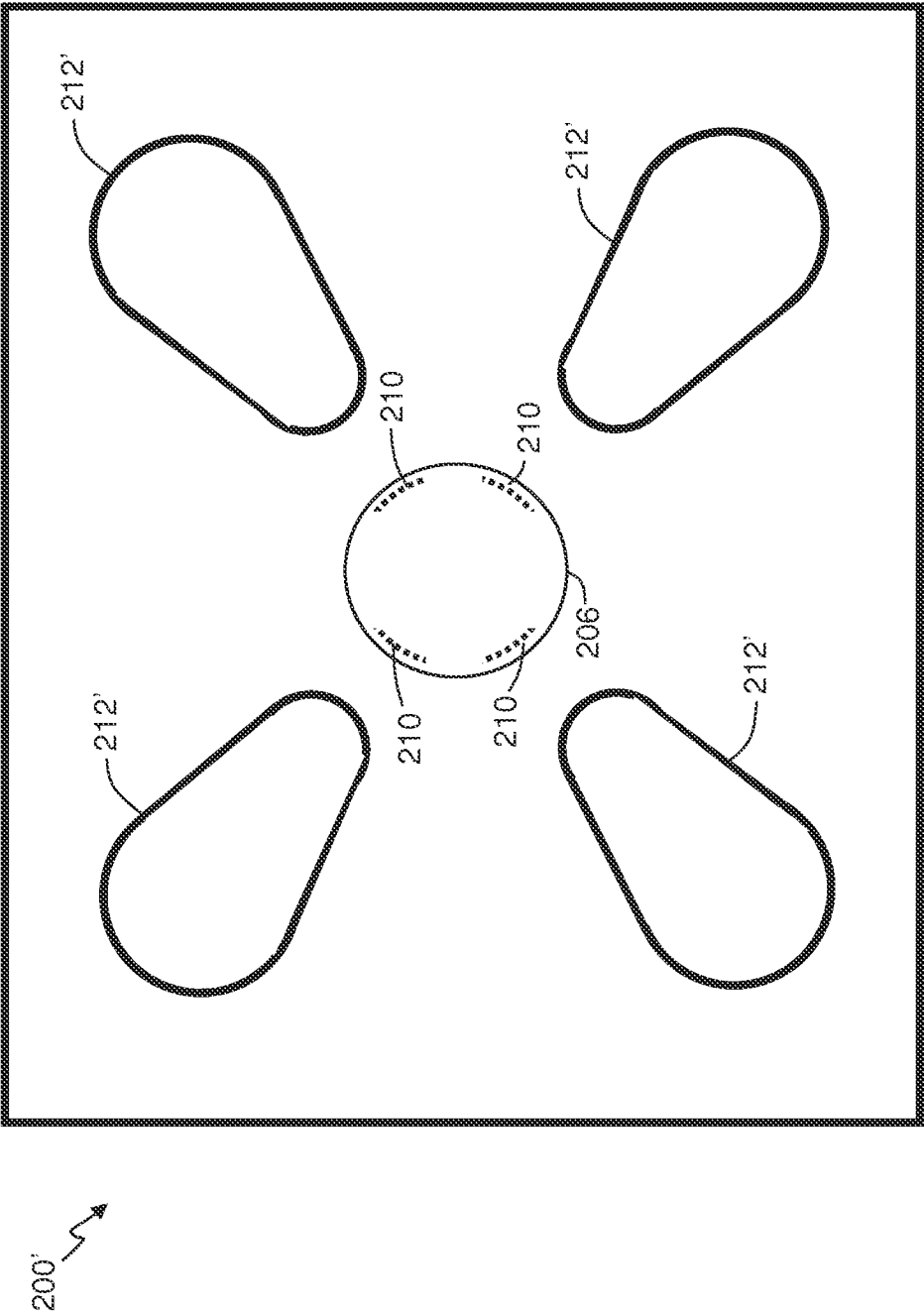


FIG. 2B

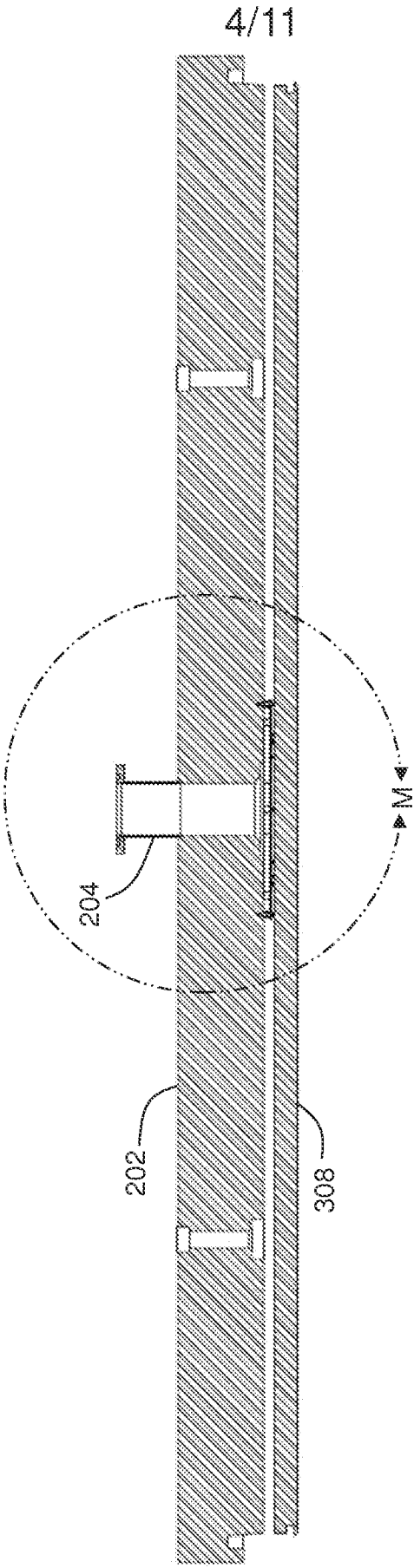


FIG. 3

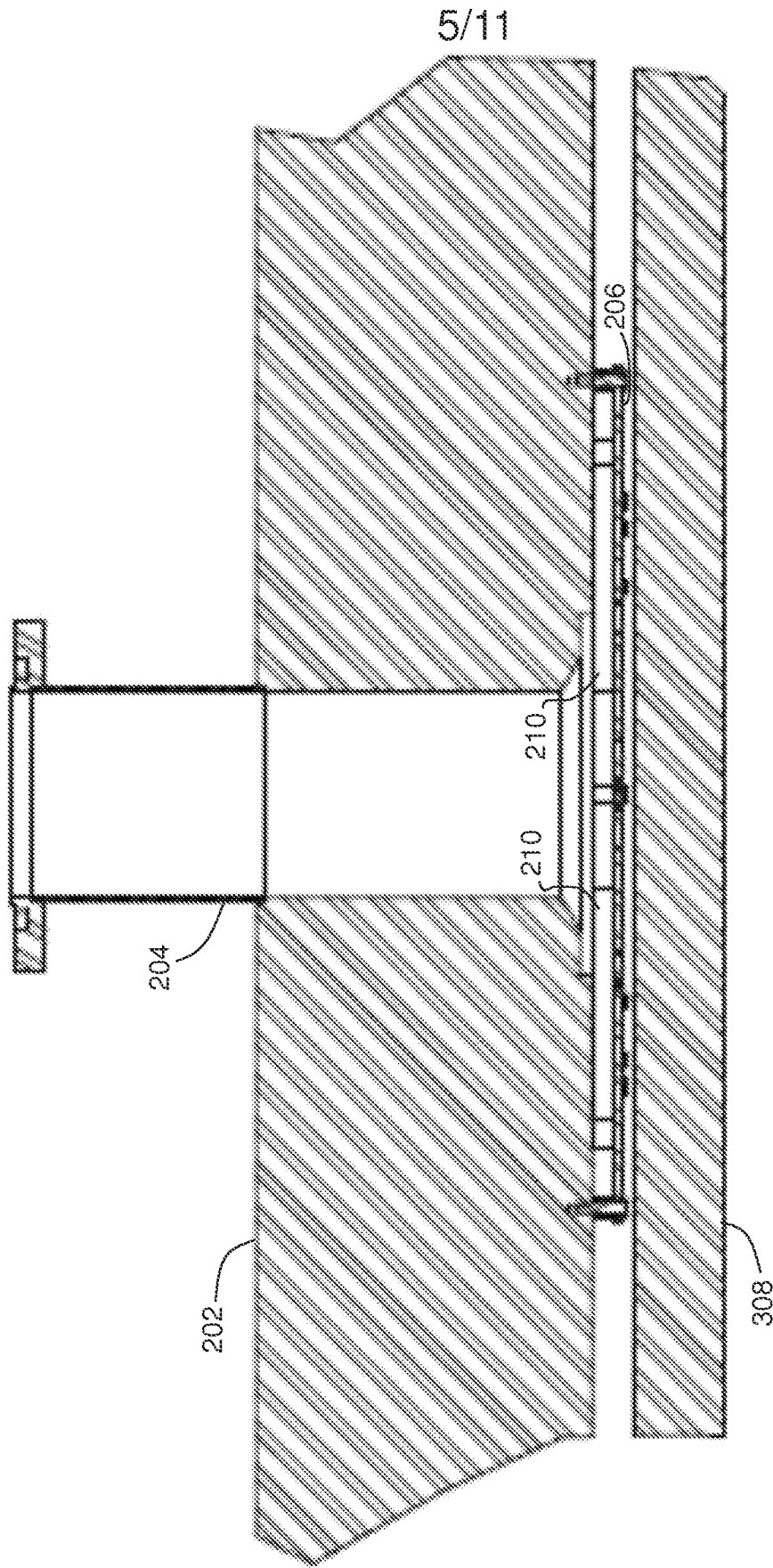


FIG. 4

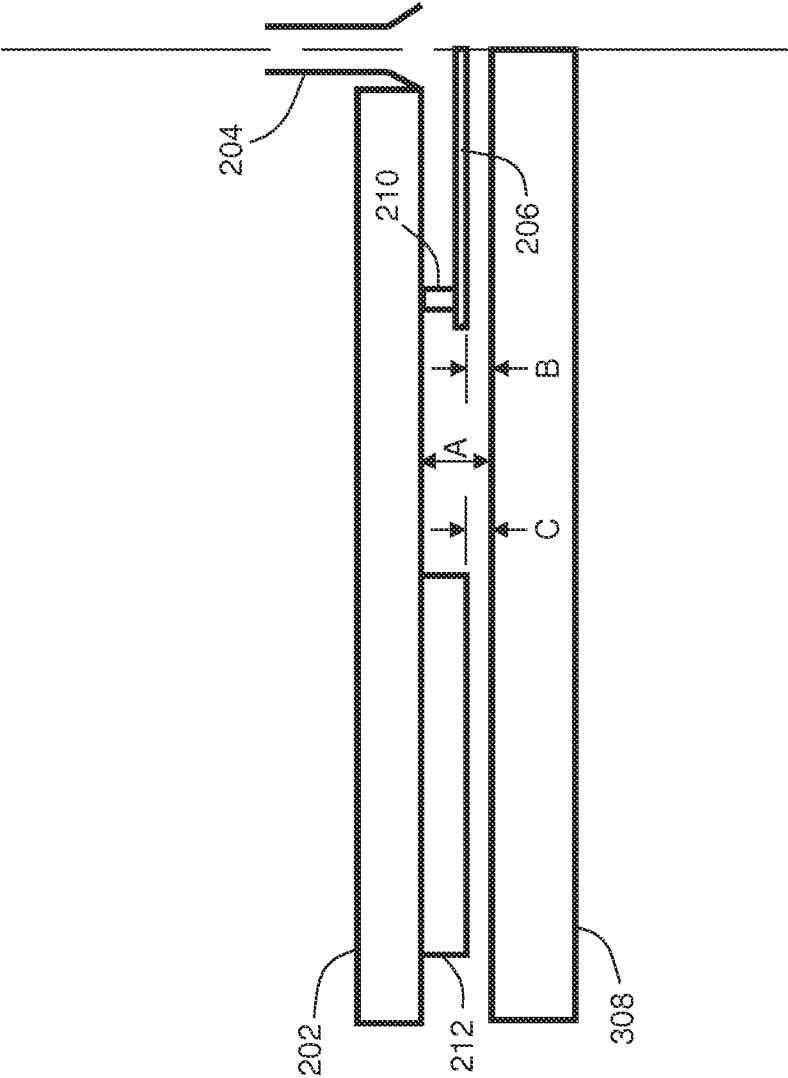


FIG. 5A

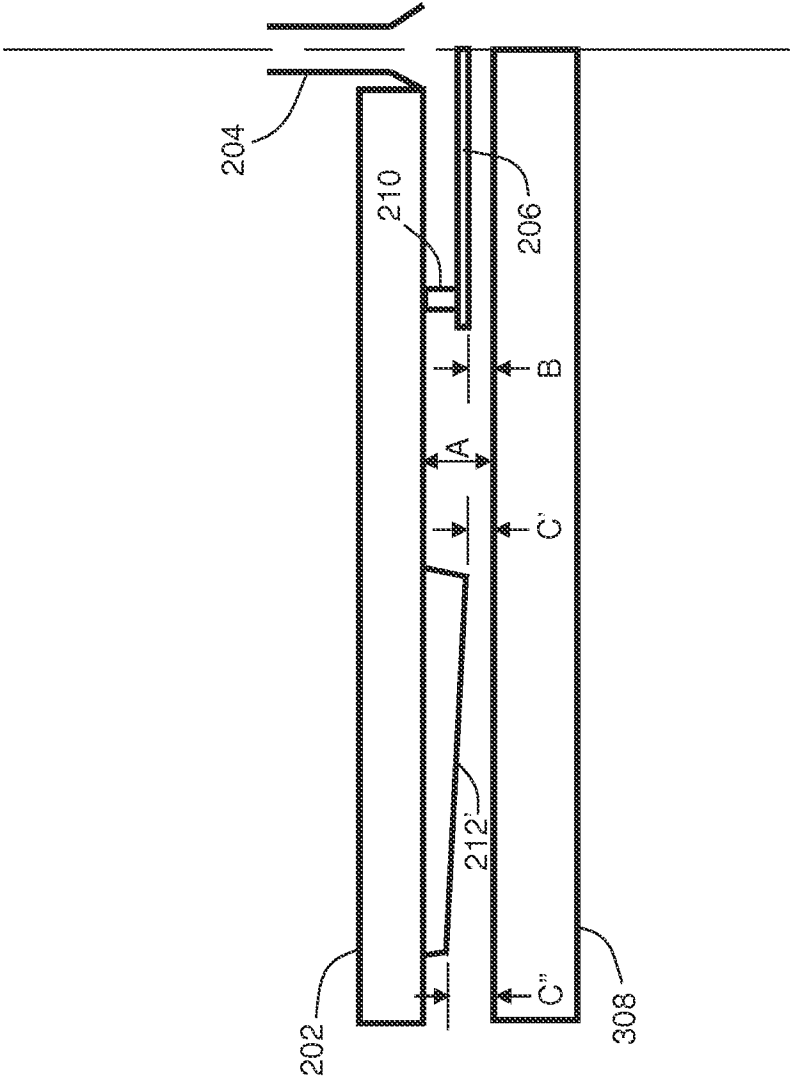


FIG. 5B

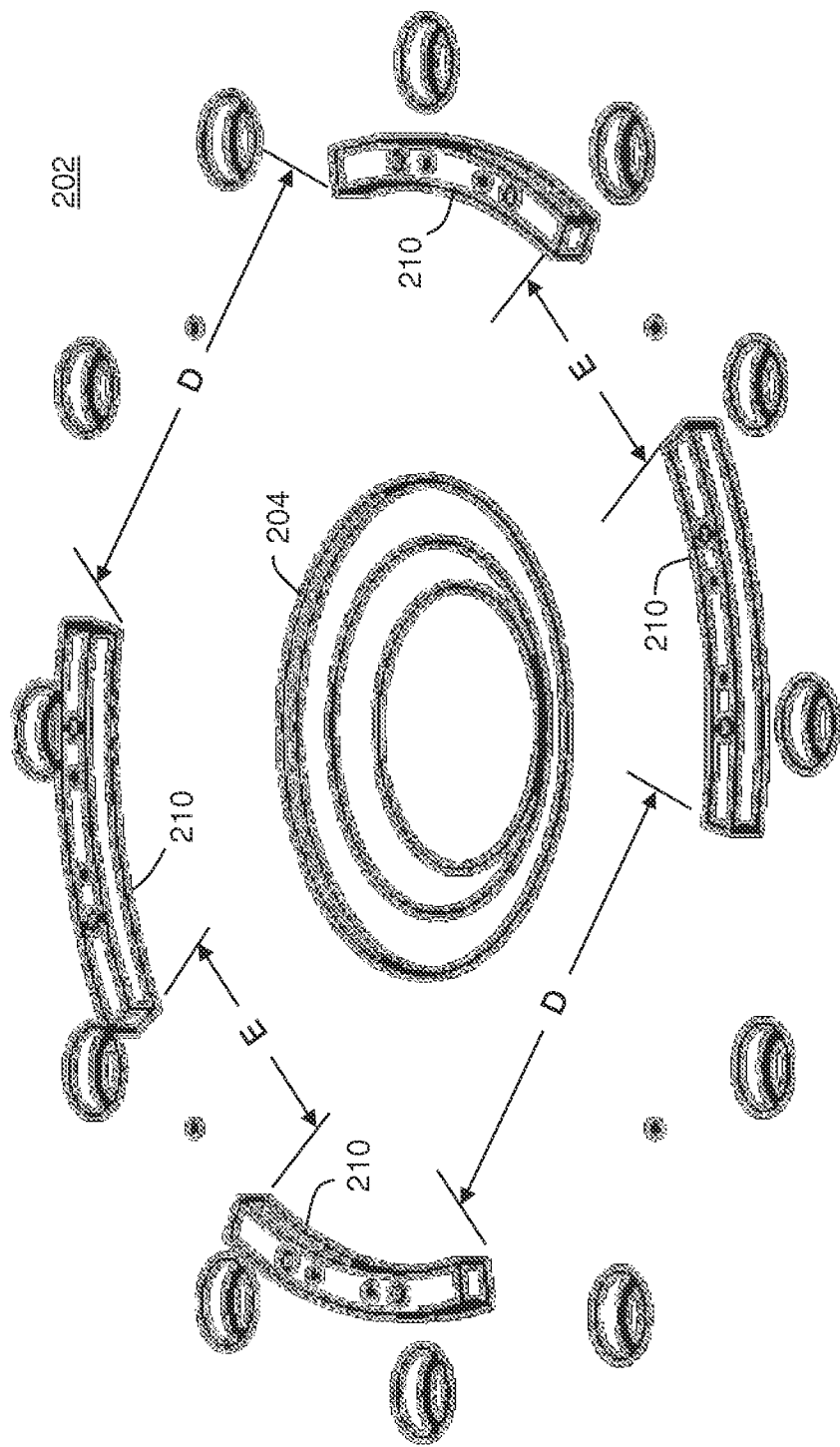
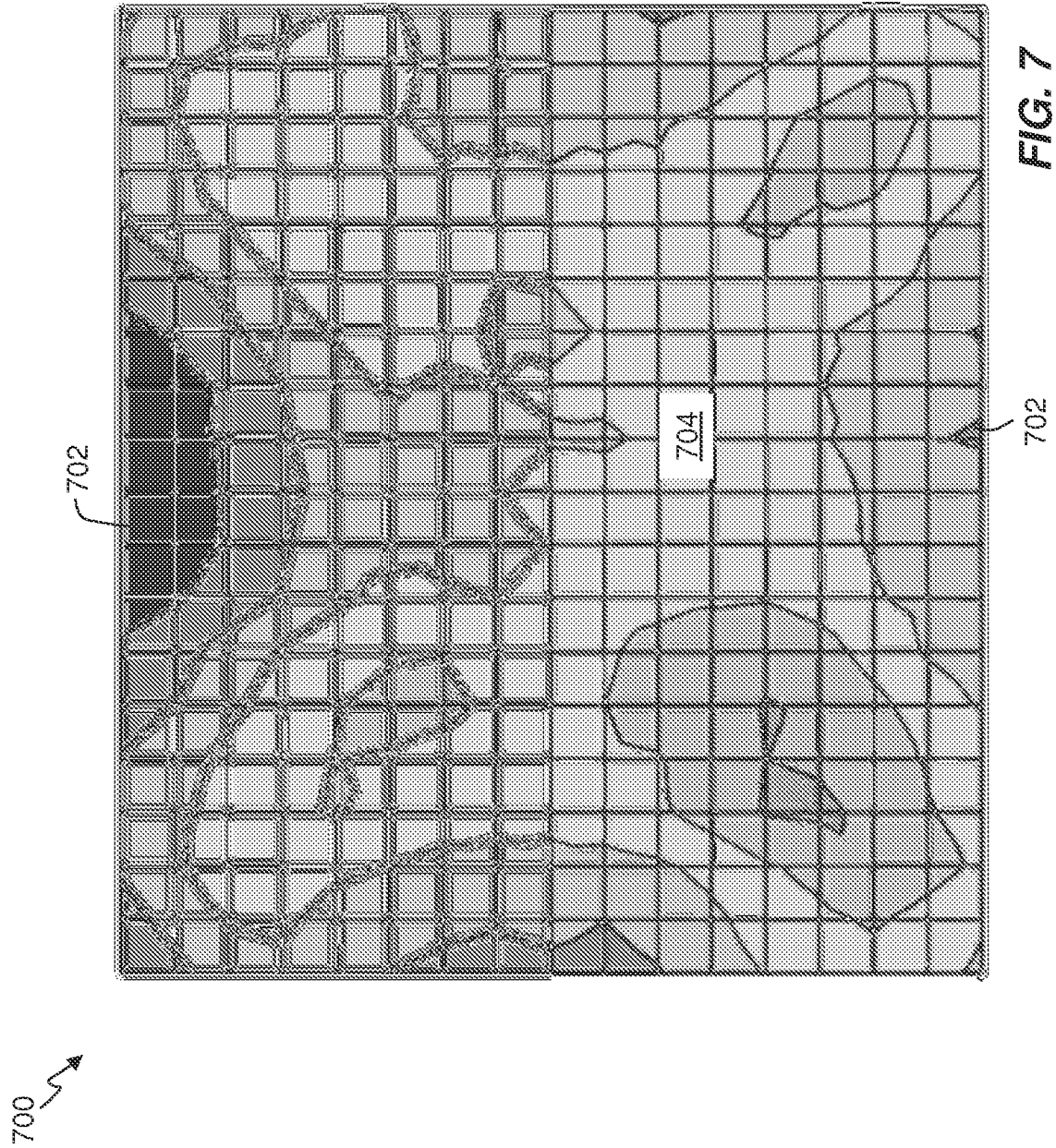


FIG. 6

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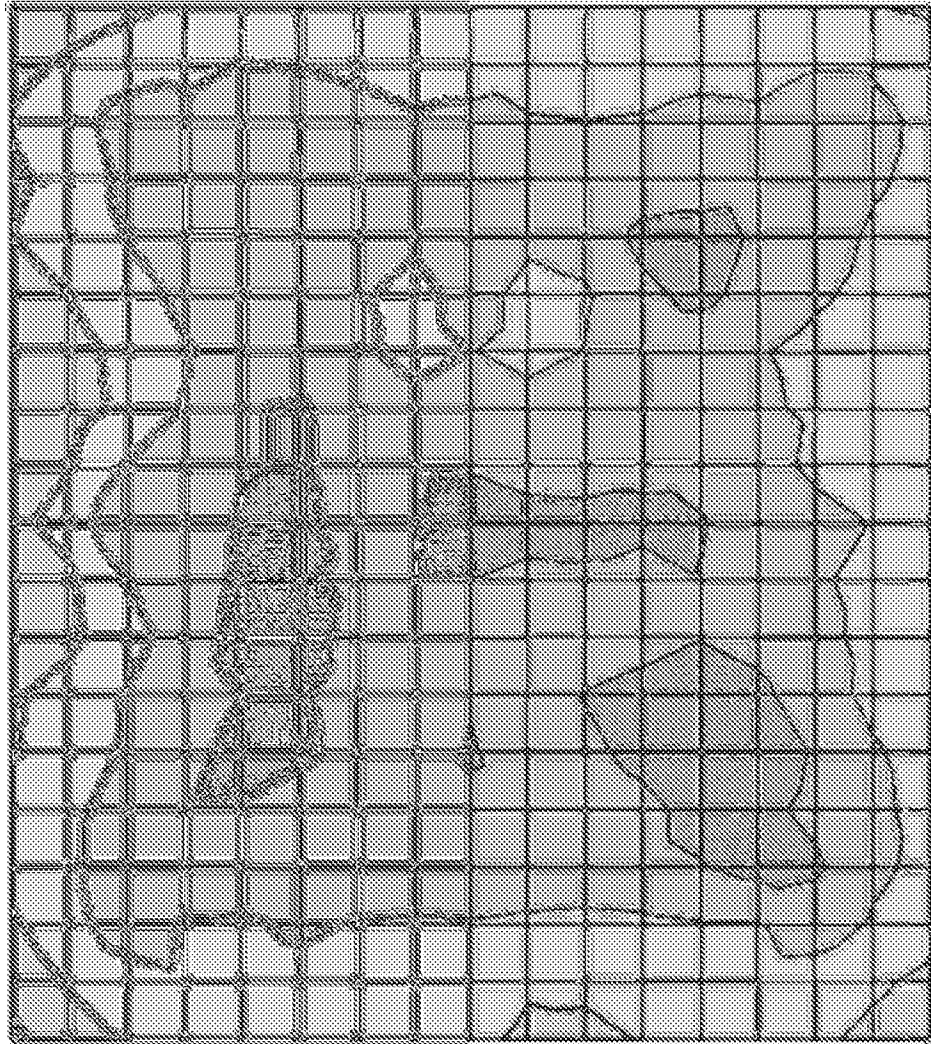


FIG. 8

800 ↗

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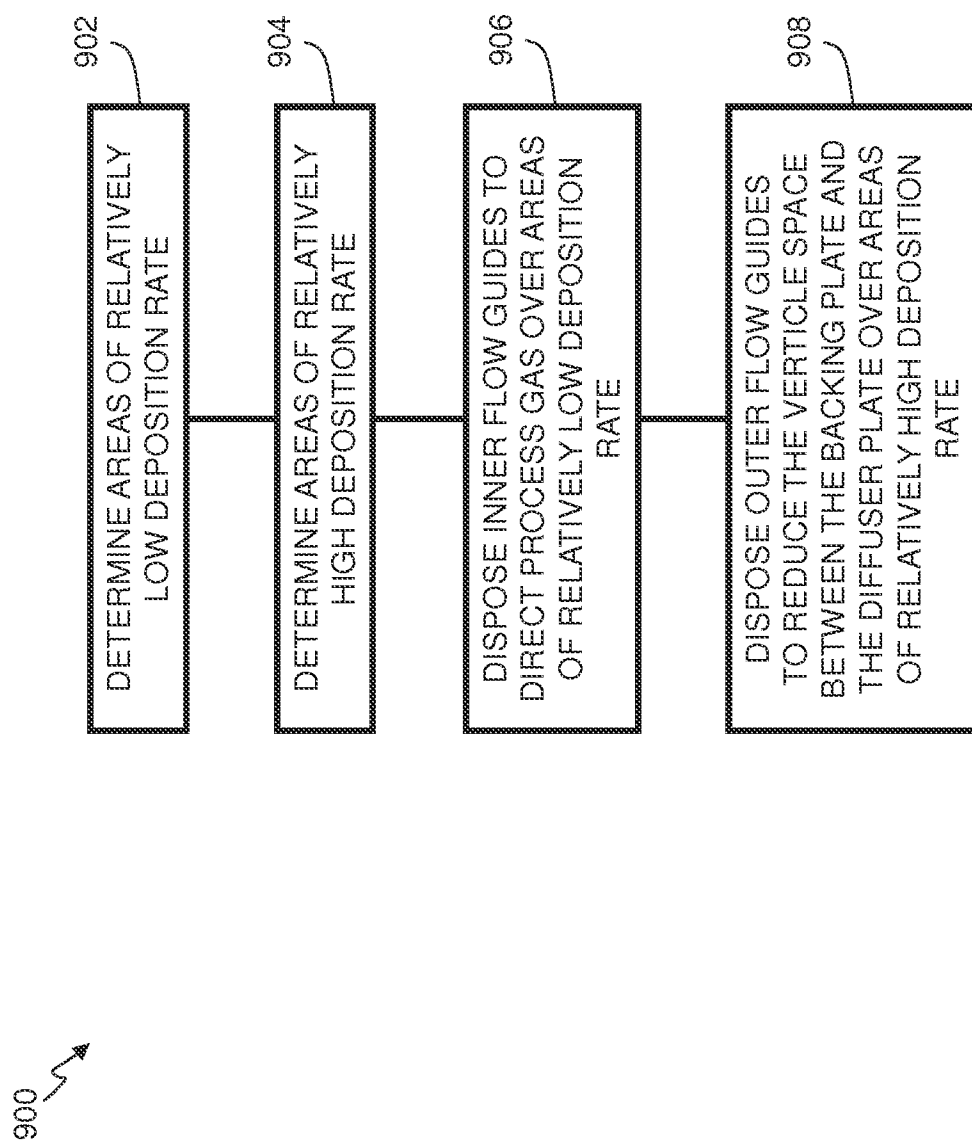


FIG. 9

A. CLASSIFICATION OF SUBJECT MATTER**C23C 16/455(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 16/455; H01L 21/46; H01L 21/205; C23C 16/54; C23C 16/44; C23C 16/00

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: gas, flow, diffusion, shower head, guide, and lateral

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012-0174866 A1 (HUH et al.) 12 July 2012 See paragraphs [0066]–[0102] and figures 3-4, 7-12.	1-20
A	US 2010-0311249 A1 (WHITE et al.) 09 December 2010 See paragraphs [0028]–[0044] and figures 2-7.	1-20
A	JP 2012-28732 A (SHARP CORP.) 09 February 2012 See paragraphs [0037]–[0081] and figures 3-9.	1-20
A	US 2009-0136665 A1 (CHOI et al.) 28 May 2009 See paragraphs [0040]–[0077] and figures 2-5.	1-20
A	US 7147718 B2 (JURGENSEN et al.) 12 December 2006 See paragraphs [0018]–[0031] and figures 1-2.	1-20



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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

21 November 2013 (21.11.2013)

Date of mailing of the international search report

21 November 2013 (21.11.2013)

Name and mailing address of the ISA/KR


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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/051572

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US 7147718 B2	12/12/2006	AU 2001-79746 A1 DE 10043601 A1 DE 50111816 D1 EP 1313897 A1 EP 1313897 B1 JP 2004-507898 A JP 4587640 B2 US 2004-0005731 A1 WO 02-18680 A1	13/03/2002 14/03/2002 15/02/2007 28/05/2003 03/01/2007 11/03/2004 24/11/2010 08/01/2004 07/03/2002