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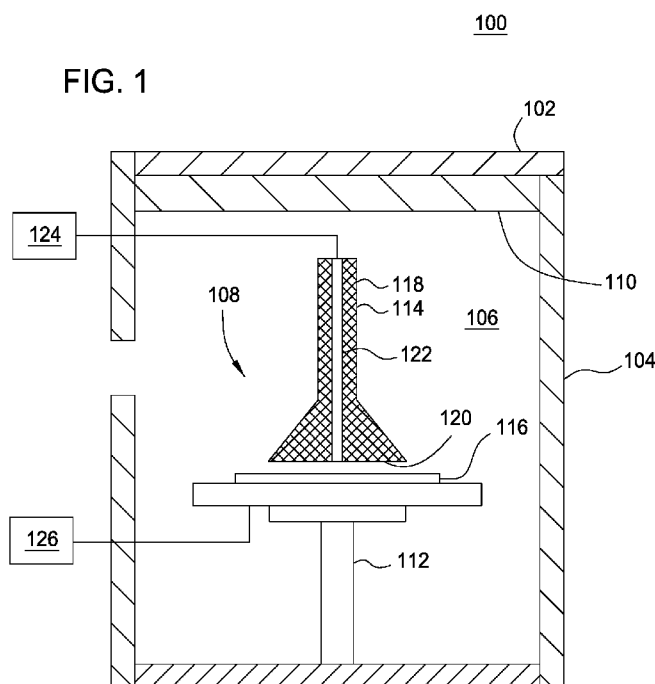
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- (54) Title: METHOD AND APPARATUS FOR SURFACE NANOPARTICLE MEASUREMENT



(57) Abstract: Embodiments described herein generally relate to a particle collection apparatus and probe head for the collection of particles on process tool components. In one embodiment, a particle collection apparatus for counting particles present on a processing tool component is disclosed herein. The particle collection apparatus includes a particle collector. The particle collector is configured to scan a processing tool component and collect particles collected from the processing tool component. The particle collector includes a body and a probe head coupled to the body. The probe head has a probe body and a controlled spacing element. The controlled spacing element is coupled to the probe body and is configured to form a uniform manifold between the probe body and the processing tool component.

METHOD AND APPARATUS FOR SURFACE NANOPARTICLE MEASUREMENT

BACKGROUND

[0001] Field

[0002] Embodiments described herein relate to cleanliness control of process tool components, and more specifically to a particle collection apparatus and probe head for the collection of particles on process tool components.

[0003] Description of the Related Art

[0004] Substrate processing tool cleanliness “out of the box” is becoming an increasingly important issue during tool start-up. To consistently deliver clean tools, it is helpful to control cleanliness of substrate processing tools at the component and subsystem levels throughout the various stages of manufacturing and assembly. To control cleanliness, it is helpful to be able to measure cleanliness of the substrate processing tools at the desired particle sizes.

[0005] Substrate processing tools often involved complex geometries. The issue of measuring particle concentration on components of various materials and potentially complex geometry is different from the issue of measuring and characterizing particle levels on essentially planar substrates. Although metrology tools capable of detecting particles in the size range of 26 nm and below are available for substrates, and particles smaller than 26 nm can be imaged and measured on small samples that are capable of being placed in a scanning electron microscope (SEM), there are no commercial or high-volume manufacturing-worthy products available to measure particle concentration in the desired size range on the majority of the components that make up the substrate processing tools. Leading semiconductor industry roadmaps project critical defect size as half design rule critical dimensions (e.g., critical defect size of 10 nm for 20 nm node, and 5 nm critical defect size for 10 nm nodes). Current state of the art in surface particle metrology for substrate processing tool components (as opposed to substrates) is limited to particle sizes greater than or equal to 100 nm. In order to ensure the appropriate cleanliness of the substrate processing environment, all component surfaces in the substrate

processing tool must be maintained at a certain level of cleanliness. This requirement extends throughout the entire tool manufacturing process.

[0006] Therefore, there is a need for devices and methods for improved particle detection on substrate processing tool components.

SUMMARY

[0007] Embodiments described herein generally relate to a particle collection apparatus and probe head for the collection of particles on process tool components. In one embodiment, a particle collection apparatus for counting particles present on a processing tool component is disclosed herein. The particle collection apparatus includes a particle collector. The particle collector is configured to scan the processing tool component and collect particles collected from a processing tool component. The particle collector includes a body and a probe head coupled to the body. The probe head has a probe body and a controlled spacing element. The controlled spacing element is coupled to the probe body and is configured to form a uniform manifold between the probe body and the processing tool component.

[0008] In another embodiment, a particle collecting apparatus is disclosed herein. The particle collecting apparatus includes a body, a probe head coupled to the body, and a counter. The probe head has a probe body and a controlled spacing element. The controlled spacing element is coupled to the probe body and is configured to form a uniform manifold between the probe body and the processing tool component. The counter configured to collect particles from a surface of a processing tool component

[0009] In another embodiment, a method of collecting particles from a surface of a processing tool component is disclosed herein. The method includes maintaining a constant volume between a particle collector and the processing tool component, providing gas to a surface of the processing tool component, dislodging particles from the processing tool component, collecting the dislodged particles from the processing tool component, and counting the dislodged particles.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] 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.

[0011] Figure 1 illustrates a clean room environment for particle detection of processing tool component parts, according to one embodiment.

[0012] Figure 2A illustrates a probe head for use in the clean room environment of Figure 1, according to one embodiment.

[0013] Figure 2B illustrate a top view of the probe head of Figure 2A.

[0014] Figure 2C illustrates a probe head for use in the clean room environment of Figure 1, according to one embodiment.

[0015] Figure 2D illustrates a top view of the probe head of Figure 2C.

[0016] Figure 3 illustrates a probe head for use in the clean room environment of Figure 1, according to one embodiment.

[0017] Figure 4 illustrates a probe head for use in the clean room environment of Figure 1, according to one embodiment.

[0018] Figure 5 illustrates a probe head for use in the clean room environment of Figure 1, according to one embodiment.

[0019] Figure 6 illustrates a clean room environment for particle detection of processing tool component parts, according to one embodiment.

[0020] Figure 7A illustrates a probe head for use in the clean room environment of Figure 6, according to one embodiment.

[0021] Figure 7B illustrates a top view of the probe head of Figure 7A.

[0022] Figure 8 illustrates a probe head for use in the clean room environment of Figure 6, according to one embodiment.

[0023] Figure 9 illustrates a probe head for use in the clean room environment of Figure 6, according to one embodiment.

[0024] Figure 10 illustrates a method of collecting particles from a surface of a processing tool component, according to one embodiment.

[0025] For clarity, identical reference numerals have been used, where applicable, to designate identical elements that are common between figures. Additionally, elements of one embodiment may be advantageously adapted for utilization in other embodiments described herein.

DETAILED DESCRIPTION

[0026] Figure 1 illustrates a clean room environment 100 for detecting particles on processing tool component parts, according to one embodiment. The clean room environment 100 includes a chamber 102 having a chamber body 104 defining an interior volume 106 of the chamber 102. The chamber 102 includes a particle collection apparatus 108 and gas filter 110. The gas filter 110 is configured to reduce the number of particles in the clean room environment 100.

[0027] The particle collection apparatus 108 is configured to detect particles on processing tool component parts. The particle collection apparatus 108 includes a test bench 112 and a particle collector 114. The test bench 112 is configured to support a processing tool component 116, while a user scans the processing tool component 116 with the particle collector 114 to collect particles from the surface of the processing tool component 116. The particle collection apparatus is capable of collecting particles in the single-nanometer scale. For example, the particle collection apparatus may be capable of collecting particles having sizes from 1-2.5 nm.

[0028] The particle collector 114 includes a body 118 and a probe head 120. The probe head 120 is configured to be placed on the surface of the processing tool component 116. The probe head 120 is hollow and forms a uniform manifold

between the probe head 120 and the processing tool component 116 when scanning the processing tool component. The uniform manifold minimizes the chances of user error by maintaining a constant volume between the probe head 120 and the processing tool component 116. If the volume changes while scanning, particles may be flushed into or out of the probe head 120, which will lead to poor test results. An exhaust conduit 122 is formed through the body 118 of the particle collection apparatus 108 and extends to the probe head 120. The exhaust conduit 122 is coupled to a particle counter 124. The particle counter 124 is configured to pump the particles from the particle collection apparatus 108 and count the number of particles collected. Because the probe head 120 is able to collect particles at sizes of a single-nanometer scale, the particle counter 124 can provide a more accurate reading of the cleanliness of the processing tool components.

[0029] In one embodiment, the particle collection apparatus 108 further includes a power source 126 coupled to the test bench 112. The power source 126 is configured to provide a voltage to the test bench 112 to generate an electric field about the processing tool component 116. Generating the electric field excites the particles on the surface of the processing tool component 116. Exciting the particles separates the particles from the bench 112, and allows the probe head 120 to more easily collect the particles.

[0030] Figure 2 illustrates one embodiment of a probe head 200. The probe head 200 includes a probe body 202 and a controlled spacing element 204 coupled to the probe body 202. The controlled spacing element 204 forms a manifold 206 between the processing tool component 116 and the probe body 202. The controlled spacing element 204 ensures that the manifold 206 formed between the processing tool component 116 and the probe body 202 is uniform throughout the collection process. The uniform manifold 206 provides consistent flow conditions that lead to a more accurate particle collection process. In the embodiment illustrated in Figure 2, the controlled spacing element 204 is a filter ring 205. The filter ring 205 allows ambient gas in the clean room environment 100 to be pulled into the manifold 206 by the particle counter 124 to separate the particles from the processing tool component 116. The gas may be pumped into the manifold 206 at a speed sufficient to separate the particles from the surface of the processing tool component 116. In one

embodiment, a turbulent flow of gas is created in the manifold 206. In another embodiment, gas is pumped through the manifold 206 at a sonic speed.

[0031] Figure 2B illustrates a top view of the probe head 200. The filter ring 205 includes a plurality of holes 208 distributed along the circumference of the filter ring 205. In one embodiment, the plurality of holes 208 is distributed uniformly around the circumference of the filter ring 205 such that incoming gas is distributed uniformly around the circumference. In another embodiment, the plurality of holes 208 is distributed asymmetrically around the circumference of the filter ring 205 to create a turbulent gas flow. In one embodiment, each hole 208 in the filter ring 205 has its own respective filter. In another embodiment, the holes may be angled to create a swirl of gas (i.e., turbulence) in the manifold 206. The gas is used to detach the particles from the surface of the processing tool component 116 such that the particles are more easily exhausted to the particle counter 124. The implementation of the filter ring 205 as the controlled spacing element also allows the gas entering the manifold 206 to be re-circulated. Recirculating the gas decreases the filter load because the filtered gas is making multiple trips through the filter ring 205.

[0032] The probe head 200 further includes an opening 210 formed about a center of the probe body 202. Forming the opening 210 about the center of the probe body 202 allows gas to enter the manifold 206 and exit the manifold 206 uniformly through the opening 210. In another embodiment, such as that shown in Figure 2C, an opening 210' is formed at a position offset from the center of the probe body 202. The offset positioning of the opening 210' is implemented with an asymmetrical hole distribution in the filter ring 205. Figure 2D illustrates the gas flow using the offset opening 210' illustrated in Figure 2C.

[0033] Figure 3 illustrates another embodiment of the probe head 300. The probe head 300 may further include an ionizer mesh ring disposed 302 disposed in the manifold 206. The ionizer mesh ring 302 is configured to neutralize the particles on the processing tool component 116 so that the exhaust conduit 122 can more easily pull the particles from the surface of the processing tool component 116.

[0034] Figure 4 illustrates another embodiment of the probe head 400. The probe head 400 includes a probe body 402. The probe body 402 is substantially similar to

the probe body 202. The probe body 402 includes an extended section 404. The extended section 404 extends farther into the manifold 206 compared to the remainder of the probe body 402, thus creating a smaller volume in the manifold 206 directly beneath the extended section 404. The change in volume in the manifold 206 creates a sonic throat 406 in the manifold. The sonic throat 406 increases the speed at which the gas flows through the manifold 206, thus creating a sonic flow. The increased flow leads to a greater particle separation potential. The greater particle separation potential leads to a greater particle collection potential, and thus more accurate tests.

[0035] Figure 5 illustrates the probe head 500, according to another embodiment. The probe head 500 includes a probe body 502 and the filter ring 205. The filter ring 205 is coupled to the probe body 502. The probe body 502 includes a reservoir ring 504 formed therein. The reservoir ring 504 is configured to increase the volume of the manifold 206 formed between the component part and the probe body 502. Increasing the volume of the manifold 206 slows down the rate at which the particles exit through the opening 210, into the conduit 122, because the reservoir ring 504 collects dislodged particles in the increased volume. This allows the collection rate of the particle collector to match to rate at which the particle counter counts the particles, thus providing a more accurate reading. In one embodiment, the probe body 502 may also include an extended section, positioned between the reservoir ring 504 and the opening 210, to form a sonic throat such as that formed by extended section 404 in Figure 4.

[0036] Figure 6 illustrates a clean room environment 600 for particle detection of processing tool component parts, according to another embodiment. The clean room environment 600 is substantially similar to clean room environment 100. The clean room environment 600 includes a particle collection apparatus 608. The particle collection apparatus 608 is configured to detect particles on processing tool components.

[0037] The particle collection apparatus 608 includes the test bench 112 and a particle collector 614. The particle collector 614 is configured to scan the surface of the processing tool component 116 and collect any particles that may be present on its surface. The particle collector 614 is capable of collecting particles in the single-

nanometer scale. The particle collector 614 includes a body 618 and a probe head 620. The probe head 620 is configured to be placed on the surface of the processing tool component 116. The probe head 620 forms a uniform manifold between the probe head 620 and the processing tool component 116 when scanning the processing tool component 116.

[0038] An exhaust conduit 622 is formed through the body 618 of the particle collector 614 and extends to the probe head 620. The exhaust conduit 622 is coupled to the particle counter 124. The particle counter 124 is configured to pump the particles from the particle collection apparatus 108 and count the number of particles collected. Because the probe head 620 is able to collect particles having sizes in the single-nanometer scale, the particle counter 124 can provide a more accurate reading of the cleanliness of the processing tool components 116. A gas inlet 624 is formed through the body 618 of the particle collector 614 and extends to the probe head 620. The gas inlet 624 is configured to provide gas to the surface of the processing tool component 116 to separate the particles from the processing tool component 116. In one embodiment, the gas inlet 624 is parallel to the exhaust conduit 622. In another embodiment, the gas inlet 624 is angled with respect to the exhaust conduit 622. The gas inlet 624 is coupled to a gas source 626. The gas source 626 may provide a gas such as air, nitrogen, or other clean gas. A filter 628 may be positioned between the gas source 626 and the gas inlet 624 to filter the gas entering the gas inlet 624. In one embodiment, the gas may be provided to the surface of the processing tool component 116 at a steady rate. In another embodiment, the gas may be provided to the surface of the processing tool component 116 at a pulsed rate.

[0039] In another embodiment, the gas inlet 624 may be used to provide a fluid to the surface of the processing tool component 116. The fluid is used to separate the particles from the processing tool component for collection. In this embodiment, a drying module (not shown) is used to quickly dry the processing tool component 116.

[0040] Figure 7A illustrates a probe head 700 for use in particle collection apparatus 608, according to one embodiment. The probe head 700 includes a probe body 702 and a controlled spacing element 704. The controlled spacing element 704 is coupled to the probe body 702. The controlled spacing element 704 forms a

manifold 706 between the processing tool component 116 and the probe body 702. The controlled spacing element 704 ensures that the manifold 706, formed between the processing tool component 116 and the probe body 702, is uniform throughout the collection process. The uniform manifold 706 provides consistent flow conditions that lead to a more efficient particle collection. In the embodiment illustrated in Figure 7, the controlled spacing element 704 is a seal, such as a gasket or an o-ring. The controlled spacing element 704 is configured to prevent gas from escaping the manifold 706 and ambient gas from entering the manifold 706.

[0041] Figure 7B illustrates a top view of the probe head 700. The probe body 702 further includes a gas inlet 708 and a particle outlet 710. The gas inlet 708 is in communication with the gas inlet 624. In one embodiment, the gas inlet 708 may be substantially perpendicular to the surface of the processing tool component 116. In another embodiment, the gas inlet 708 may be angled with respect to the surface of the component part. For example, the gas inlet 708 may be formed at an angle of about 30° with respect to the surface of the processing tool component 116. Angling the gas inlet 708 allows for a more efficient removal of particles from the processing tool component 116 due to the angle at which the gas contacts the particles. The particle outlet 710 is in communication with the exhaust conduit 622. The particle outlet 710 is configured to receive particles for collection.

[0042] Figure 8 illustrates one embodiment of a probe head 800 for use in particle collection apparatus 608. The probe head 800 includes a probe body 802 and the controlled spacing element 704. The probe body 802 includes a reservoir ring 808 formed therein. The reservoir ring 808 is similar to the reservoir ring 504 in Figure 5. The gas inlet 708 is formed in the reservoir ring 808 at a first side 810 of a centerline 812 of the probe head 700, and the particle outlet 710 is formed in the reservoir ring at a second side 814 of the centerline. This allows the gas entering the manifold 706 to sweep across the manifold 706 from the first side 810 to the second side 814. In one embodiment, the probe body 802 may further include an extended member, similar to extended section 404 in Figure 4, between the reservoir ring 808 and the particle outlet 710. The extended member forms a sonic throat in the manifold 706.

[0043] Figure 9 illustrates a probe head 900, according to another embodiment. The probe head 900 includes a probe body 902 and the controlled spacing element 704.

A plurality of angled gas inlets 908 is formed through the probe body 902 and open into the manifold 706. The angled gas inlets 908 may be formed at an angle less than 90 degrees with respect to the test bench. In one embodiment, the angled gas inlets 908 are coupled to the gas inlet 624. In another embodiment, the angled gas inlets 908 may be coupled to a syringe 910, configured to provide gas to the angled gas inlets. In one embodiment, the syringe may provide a steady stream of gas to the manifold 706. In another embodiment, the syringe 910 may provide a pulsed jet of gas to the manifold 706.

[0044] Figure 10 illustrates a method 1000 of collecting particles from a surface of a processing tool component, according to one embodiment. The method 1000 begins at block 1002. At block 1002, a constant volume between the particle collector and the processing tool component is maintained once established. The constant volume is maintained through the use of a controlled spacing element, such as controlled spacing element 204 in Figure 2 and 704 in Figure 7. In one embodiment, the controlled spacing element is a filter ring. In another embodiment, the controlled spacing element is an o-ring.

[0045] At block 1004, gas or other fluid is provided to the surface of the processing tool component. In one embodiment, the gas may be pumped in through a filter ring coupled to a probe body of the probe head. In another embodiment, the gas may be provided through a gas inlet formed in the probe body of the particle collector.

[0046] At block 1006, the particles are dislodged from the surface of the processing tool component. The gas provided to the surface of the processing tool component dislodges the particles. In one embodiment, a turbulent flow of gas dislodges the particles. In another embodiment, a pulsed flow of gas dislodges the particles. Dislodging the particles allows the particle collector to collect a greater number of particles from the surface of the processing tool. This is because the gas flow may dislodge particles as small as 1-2.5 nm, allowing the particle collector to collect particles of sizes not sampled by previous particle collecting techniques.

[0047] At block 1008, the particle collector collects the particles for the particle counter. The particle collector collects particles dislodged from the surface of the processing tool component. The collected particles are provided to the particle

counter for counting the number of particles present on the processing tool component.

[0048] At block 1010, the particle counter counts the number of particles collected. Knowing the number of particles collected allows the user to know the number of defects present on the substrate. This allows the user to produce substrates that are within the industry standard.

[0049] While the foregoing is directed to specific embodiments, 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. A particle collection apparatus for counting particles present on a processing tool component, the apparatus comprising:
 - a particle collector configured to scan a processing tool component and collect particles collected from the processing tool component, the particle collector, comprising:
 - a body; and
 - a probe head coupled to the body, the probe head having a probe body and a controlled spacing element, the controlled spacing element is coupled to the probe body and is configured to form a uniform manifold between the probe body and the processing tool component.
2. The particle collection apparatus of claim 1, wherein the controlled spacing element is an o-ring or gasket.
3. The particle collection apparatus of claim 2, wherein a gas inlet is formed through the probe body.
4. The particle collection apparatus of claim 2, wherein the probe body includes a reservoir ring.
5. The particle collection apparatus of claim 1, further comprising:
 - a power source coupled to the particle collection apparatus, the power source configured to excite particles from a surface of the processing tool component.
6. A particle collecting apparatus, comprising:
 - a body;
 - a probe head coupled to the body, the probe head having a probe body and a controlled spacing element, the controlled spacing element is coupled to the probe body and is configured to form a uniform manifold between the probe body and a processing tool component; and
 - a counter configured to collect particles from a surface of a processing tool component.

7. The particle collection apparatus of claim 6, wherein the body further comprises:
 - a sonic throat.
8. The particle collection apparatus of claim 7, wherein a gas inlet is formed through the probe body.
9. The particle collection apparatus according to claims 1 or 6, wherein the controlled spacing element is a filter ring.
10. The particle collection apparatus of claim 9, wherein the probe head further comprises:
 - an ionizer mesh disposed in the manifold.
11. The particle collection apparatus of claim 9, wherein the probe body includes an extended section configured to decrease a volume in the uniform manifold at positions beneath the extended section.
12. The particle collection apparatus of claim 9, wherein the probe body includes a reservoir ring.
13. A method of collecting particles from a surface of a processing tool component, comprising:
 - maintaining a constant volume between a particle collector and the processing tool component;
 - providing gas to a surface of the processing tool component;
 - dislodging particles from the processing tool component;
 - collecting the dislodged particles from the processing tool component; and
 - counting the dislodged particles.
14. The method of claim 13, wherein the gas is pulsed.

15. The method of claim 13, further comprising:
creating a turbulent flow in the constant volume.

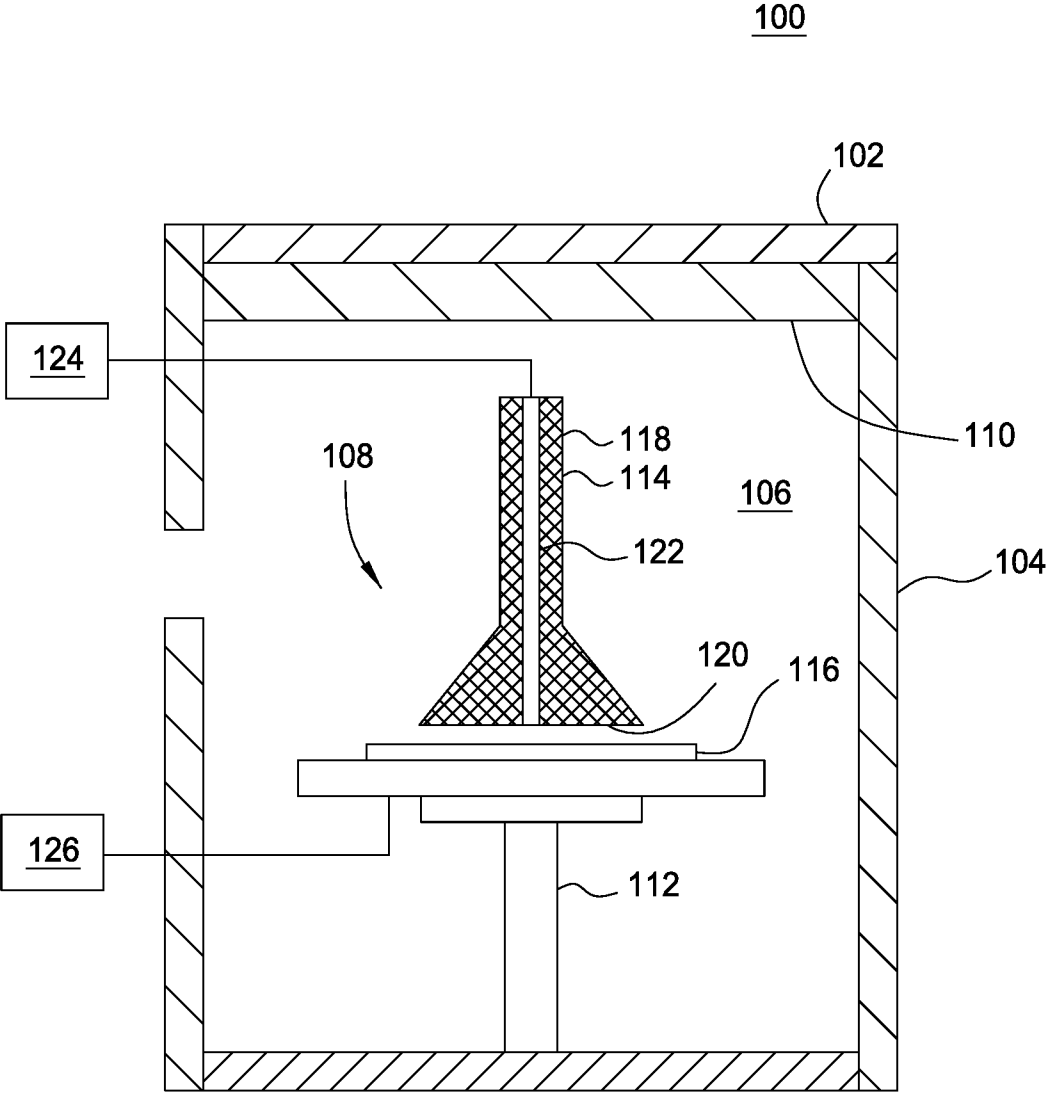


FIG. 1

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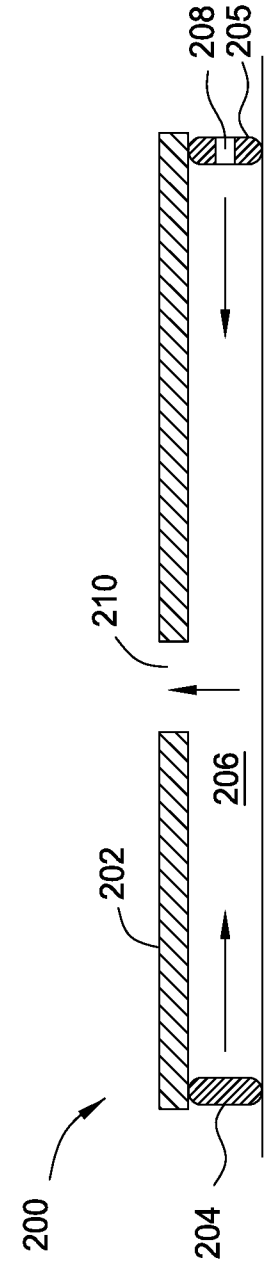


FIG. 2A

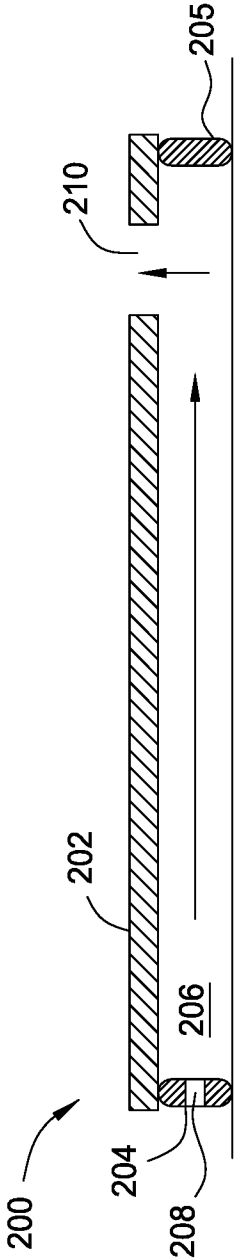


FIG. 2C

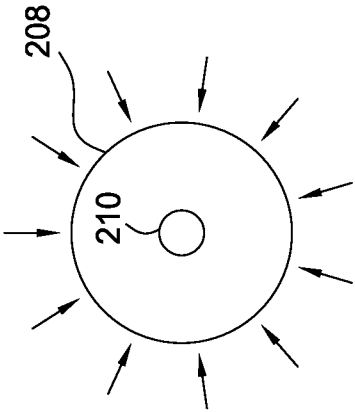


FIG. 2B

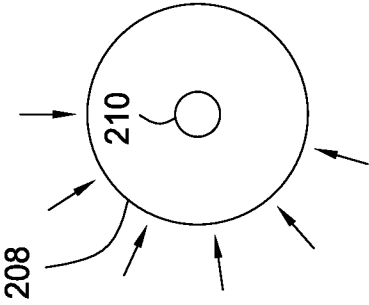


FIG. 2D

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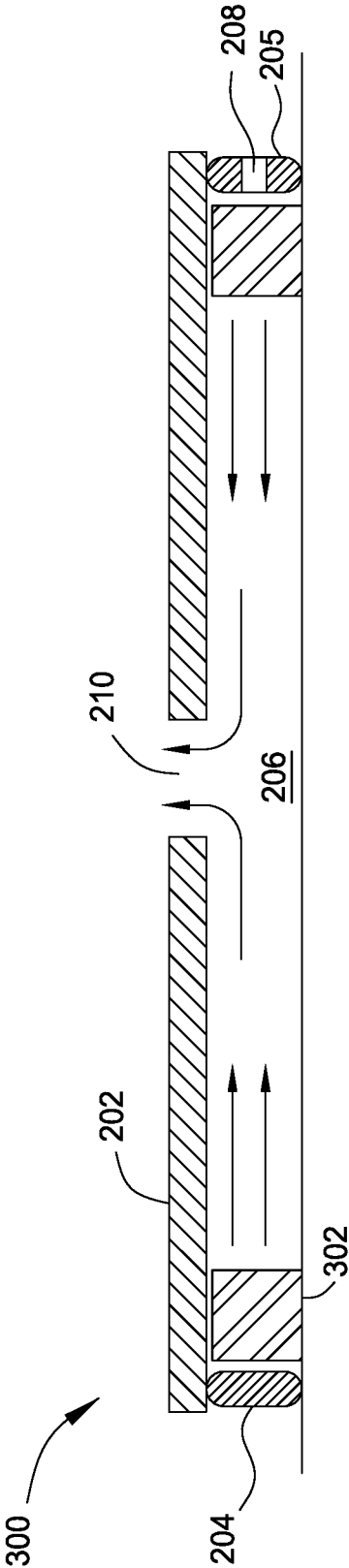


FIG. 3

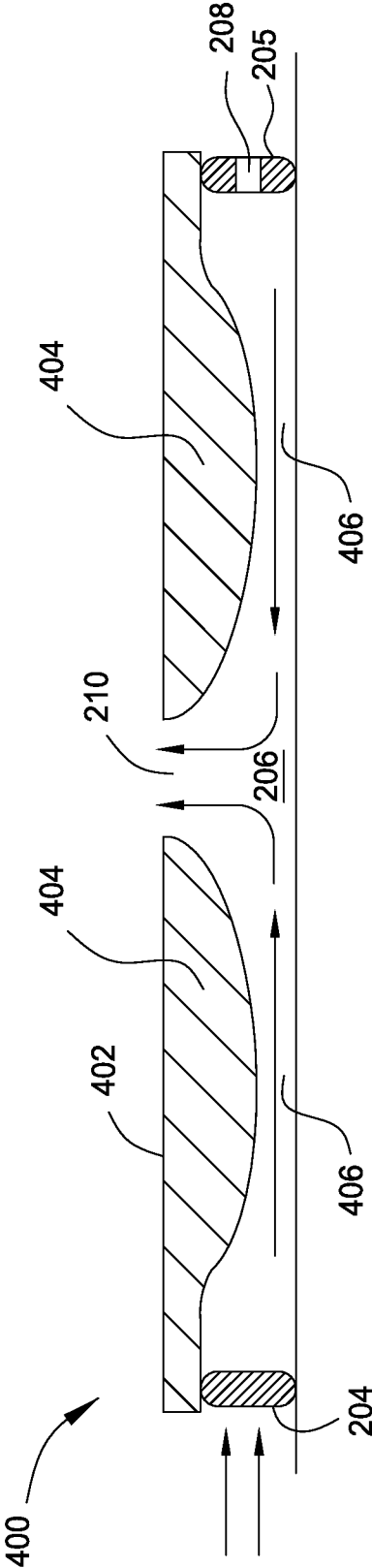


FIG. 4

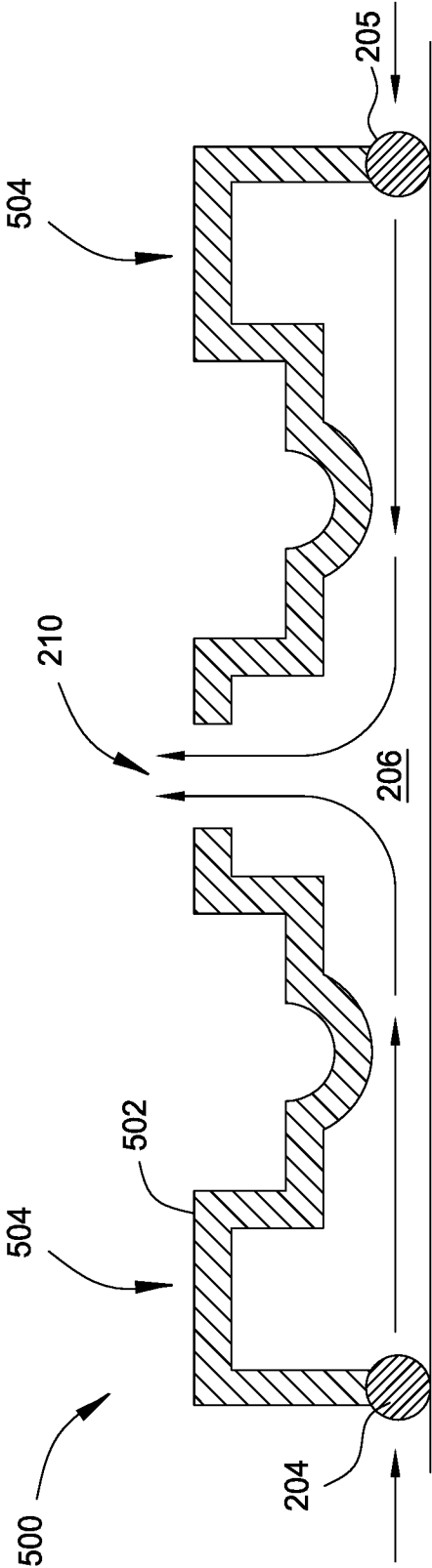


FIG. 5

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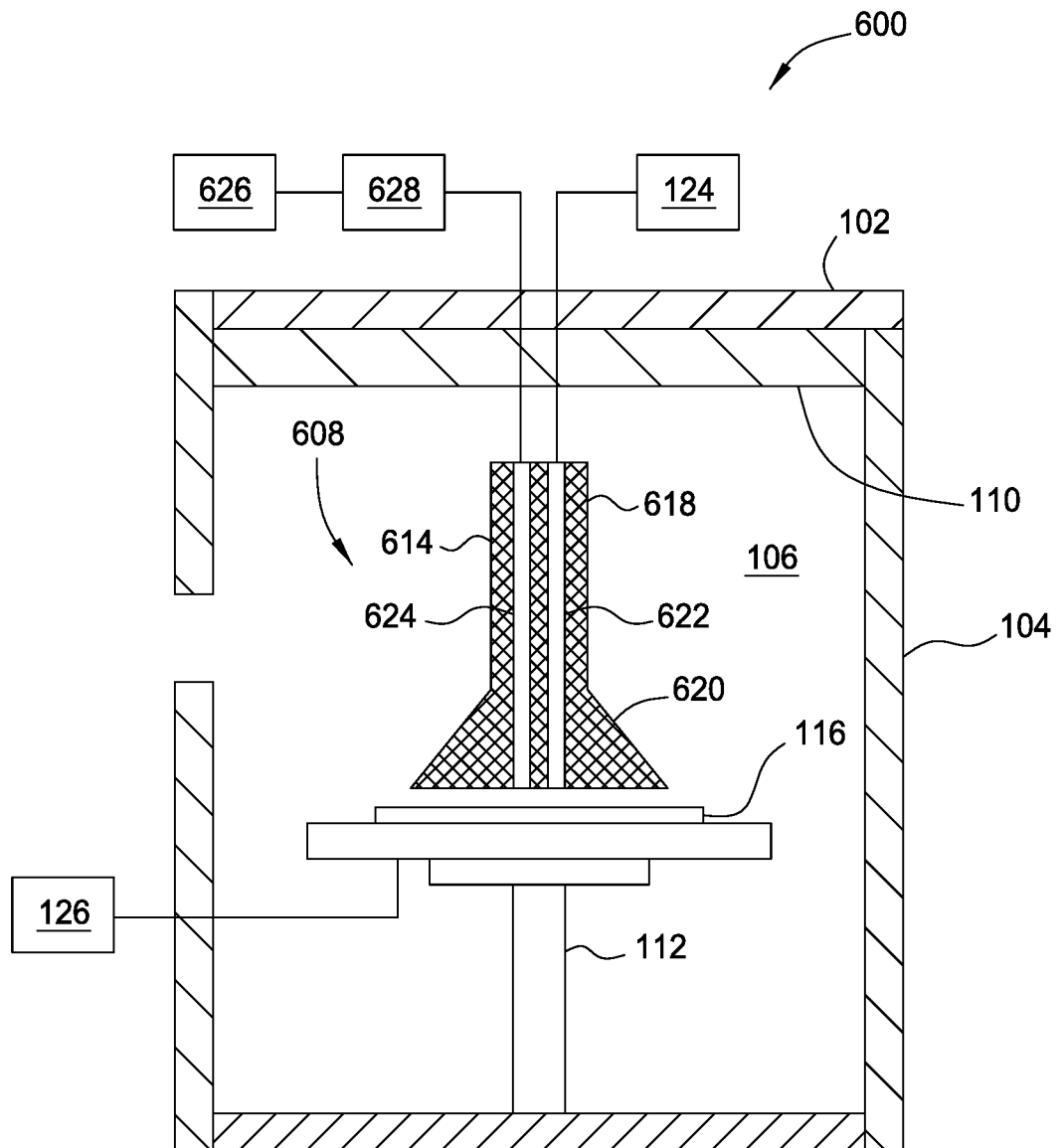


FIG. 6

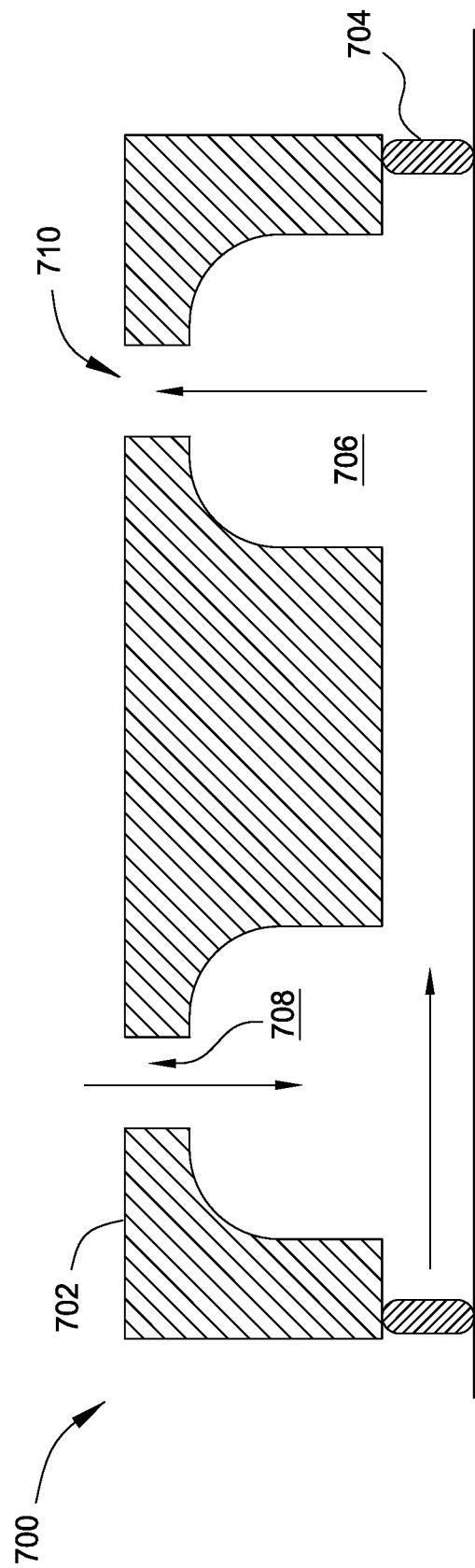


FIG. 7A

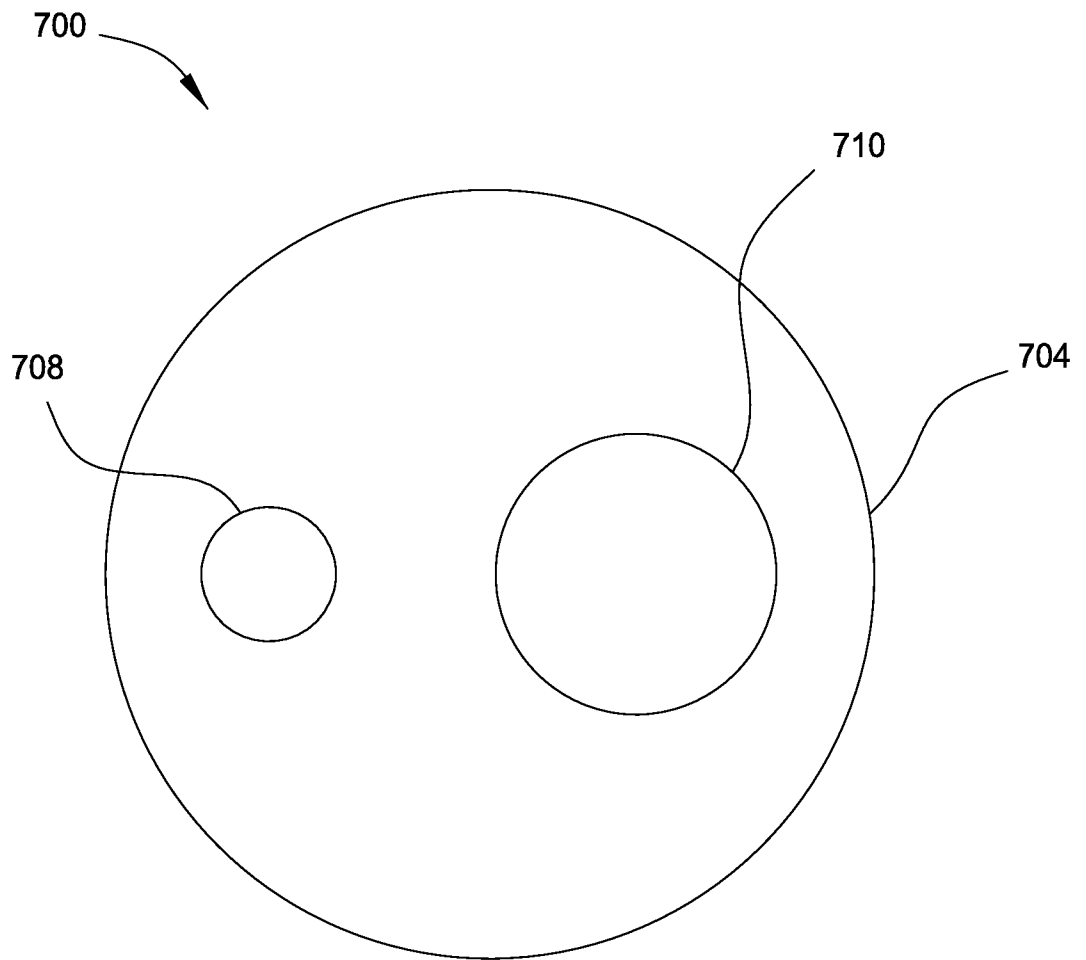


FIG. 7B

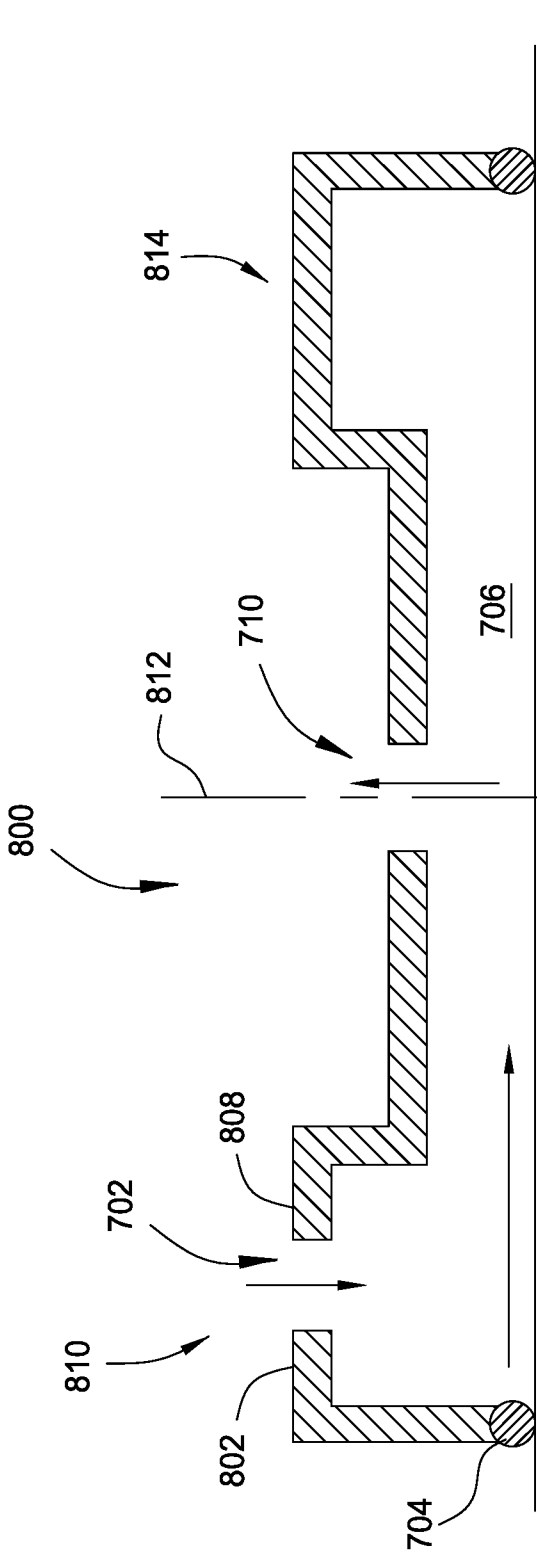


FIG. 8

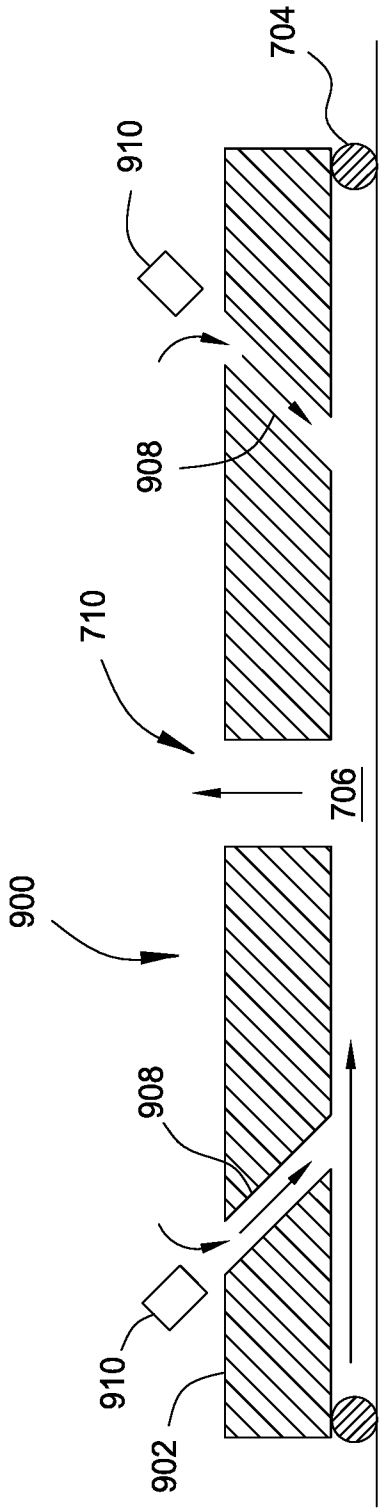


FIG. 9

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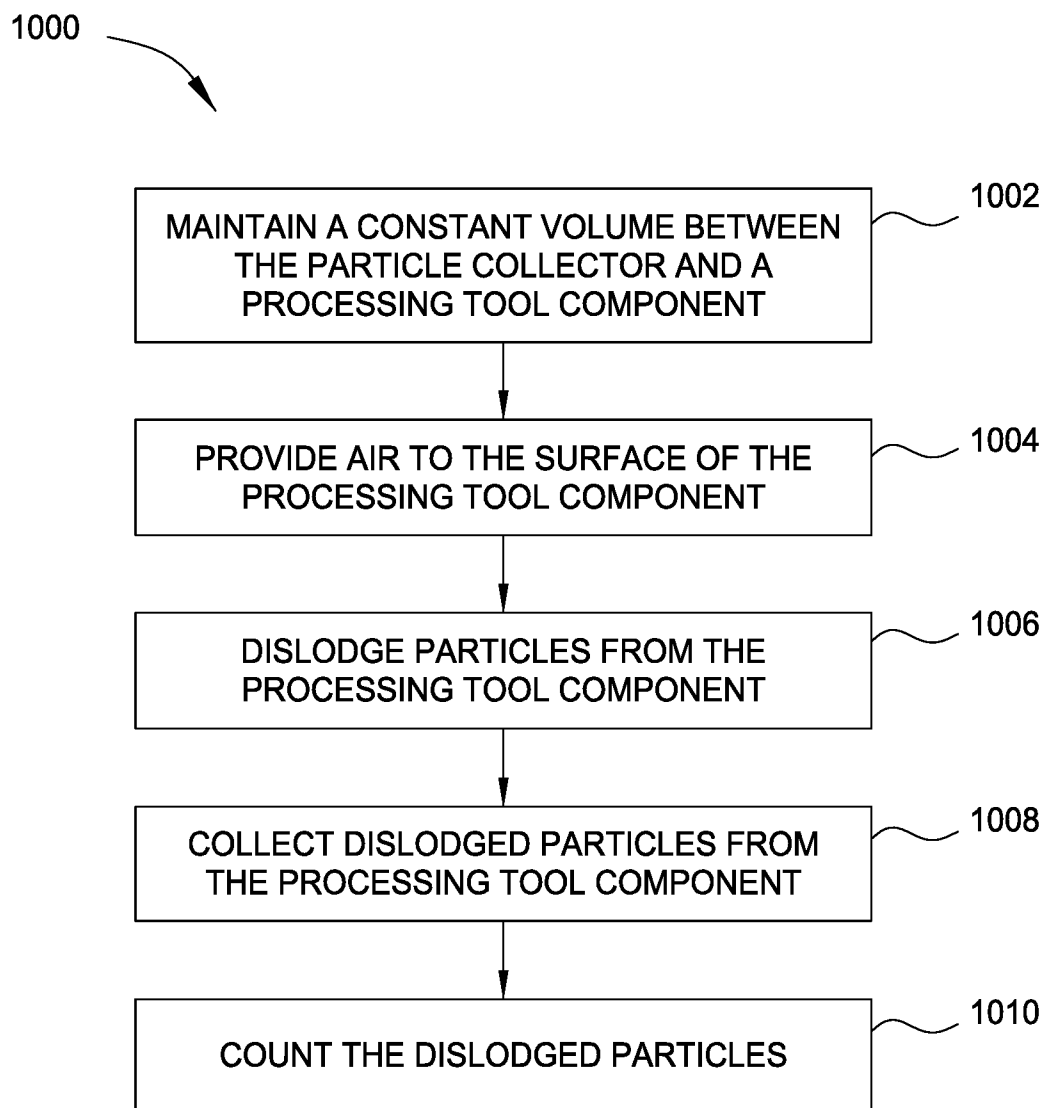


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/060238**A. CLASSIFICATION OF SUBJECT MATTER****G01N 15/00(2006.01)i**

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
G01N 15/00; G01N 19/10; G06M 11/00; G01N 1/22; B08B 3/04; G01N 25/18; B01D 46/00Documentation 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 modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: collecting, counting, particle, surface, sampling, cleanliness, spacing element, gasket, o-ring, dislodging, chamber, probe head, probe body, manifold, metrology tool**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6378385 B1 (BOWERS, WILLIAM D.) 30 April 2002 See abstract; claims 1-4; and figures 4-6C.	13-15
A		1-12
A	US 5253538 A (SWICK, ROBERT H. et al.) 19 October 1993 See abstract; column 2, line 54 - column 3, line 68; and figure 4.	1-15
A	US 2007-0107495 A1 (KIM, DONG-HYUN et al.) 17 May 2007 See abstract; and paragraphs [0059]-[0069].	1-15
A	US 2006-0185520 A1 (JORDAN SR., JOHN L. et al.) 24 August 2006 See abstract; and paragraphs [0022]-[0035].	1-15
A	US 2008-0236620 A1 (SHIH, HONG et al.) 02 October 2008 See abstract; and paragraphs [0025]-[0048].	1-15



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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/060238

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6378385 B1	30/04/2002	AU 1999-60261 A1 EP 1110072 A1 JP 2002-525567 A US 6269703 B1 WO 00-16064 A1	03/04/2000 27/06/2001 13/08/2002 07/08/2001 23/03/2000
US 5253538 A	19/10/1993	None	
US 2007-0107495 A1	17/05/2007	KR 10-0727487 B1 KR 10-2007-0051185 A	13/06/2007 17/05/2007
US 2006-0185520 A1	24/08/2006	CA 2370540 A1 CA 2370540 C CA 2650784 A1 CA 2650784 C US 2003-0075048 A1 US 2004-0107837 A1 US 2008-0229930 A1 US 6692553 B2 US 7135060 B2 US 7785408 B2	10/04/2003 03/02/2009 10/04/2003 27/03/2012 24/04/2003 10/06/2004 25/09/2008 17/02/2004 14/11/2006 31/08/2010
US 2008-0236620 A1	02/10/2008	CN 101652837 A CN 101652837 B JP 2010-523300 A JP 5258873 B2 KR 10-1455888 B1 KR 10-2010-0016006 A TW 200905745 A TW I409878 B US 7578889 B2 WO 2008-121287 A1	17/02/2010 08/06/2011 15/07/2010 07/08/2013 04/11/2014 12/02/2010 01/02/2009 21/09/2013 25/08/2009 09/10/2008