(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
2 May 2013 (02.05.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/062866 A1

(51) International Patent Classification:
C23C 16/455 (2006.01)

(21) International Application Number:
PCT/US2012/061029

(22) International Filing Date:
19 October 2012 (19.10.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
13/280,750 25 October 2011 (25.10.2011) US

(71) Applicant: **LAM RESEARCH CORPORATION** [US/US]; 4650 Cushing Parkway, Fremont, CA 94538-6470 (US).

(72) Inventors: **CHHATRE, Rish**; 1445 Fruitdale Avenue, Unit 409, San Jose, CA 95128 (US). **SCHAEFER, David**; 38827 Stillwater Cmn., Fremont, CA 94536 (US).

(74) Agent: **SKIFF, Peter, K.**; Buchanan Ingersoll & Rooney PC, P.O. Box 1404, Alexandria, VA 22313-1404 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

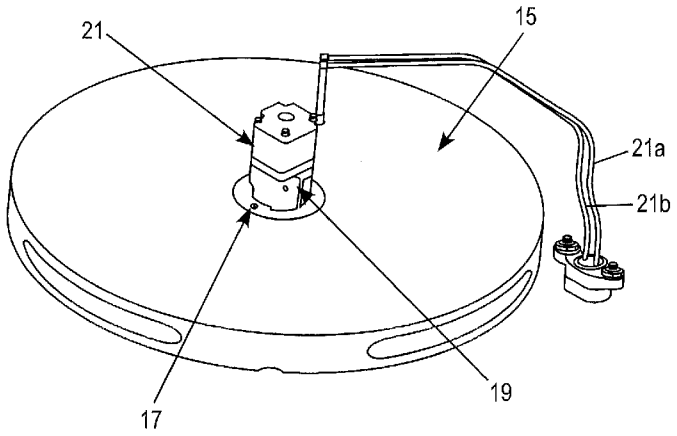
Published:

— *with international search report (Art. 21(3))*

WO 2013/062866 A1

(54) Title: WINDOW AND MOUNTING ARRANGEMENT FOR TWIST-AND-LOCK GAS INJECTOR ASSEMBLY OF INDUCTIVELY COUPLED PLASMA CHAMBER

FIG. 1



(57) Abstract: An improved gas injection assembly for mounting in a central bore of a dielectric window of an inductively coupled plasma chamber includes a window having a central bore and cylindrical recess configured to receive an annular insert having a bayonet opening. The gas injector assembly includes a gas injector, an RF shield surrounding the gas injector, and a faceplate surrounding the RF shield, the faceplate including projections at the bottom thereof for engaging the bayonet opening in the annular insert. The window and gas injection assembly are designed to avoid chipping of the window which is typically made of quartz and in prior mounting arrangements the window has a bayonet opening machined therein. Due to the brittle nature of the quartz material, the machined bayonet opening was subject to chipping when the gas injector assembly was inserted into the bayonet opening.

WINDOW AND MOUNTING ARRANGEMENT FOR TWIST-AND-LOCK GAS INJECTOR ASSEMBLY OF INDUCTIVELY COUPLED PLASMA CHAMBER

FIELD OF THE INVENTION

[0001] The invention relates to components of a plasma processing chamber in which semiconductor substrates are processed.

SUMMARY

[0002] According to one embodiment, a dielectric window of a plasma processing chamber is provided. The window forms a top wall of an inductively coupled plasma chamber wherein semiconductor substrates are plasma processed. The plasma is generated by energizing a process gas into a plasma state. The process gas is supplied into the chamber by a gas injector assembly comprising a gas injector, RF shield, faceplate and annular insert mounted in a central bore in the window. The window comprises a disk having a uniform thickness, a lower vacuum sealing surface on a lower surface thereof adapted to seal against an upper surface of the plasma processing chamber, a central bore configured to receive the gas injector which delivers process gas into the center of the plasma processing chamber, and an upper recess in the upper surface surrounding the central bore and configured to receive the annular insert used to mount the gas injector assembly in the window.

[0003] According to another embodiment, the insert is an annular insert adapted to fit in the upper recess in the dielectric window. The annular disk has a uniform thickness and is adapted to be received in the upper recess, the disk having a cylindrical outer wall, an upper surface, a lower surface, and a bayonet opening extending between the upper and lower surfaces.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** shows a replaceable window and gas injector assembly for an inductively coupled plasma reaction chamber.

[0005] FIGS. **2**A-C show cross sections of a replaceable window and gas injector assembly for a plasma reaction chamber wherein FIG. **2**A shows the gas injection assembly connected to a gas supply, FIG. **2**B shows the gas injection assembly without the gas supply attached, and FIG. **2**C shows details of a gas injector, RF shield, and faceplate held in an annular insert bolted into the dielectric window.

[0006] FIGS. **3**A-M show details of a quartz window as described herein wherein FIG. **3**A is a perspective view of the window, FIG. **3**B is a bottom view of the window, FIG. **3**C is a side view of the window along line A-A in FIG. **3**B, FIG. **3**D is a view along the line C-C in FIG. **3**E, FIG. **3**E is a top view of the window, FIG. **3**F is a view along the line D-D in FIG. **3**E, FIG. **3**G is a view of detail H in FIG. **3**D, FIG. **3**H is a view of detail K in FIG. **3**F, FIG. **3**I is a view of detail G in FIG. **3**B, FIG. **3**J is a view along the line B-B in FIG. **3**G, FIG. **3**K is a view of detail J in FIG. **3**D, FIG. **3**L is a view of detail L in FIG. **3**E, and FIG. **3**M is a view along line E-E in FIG. **3**L.

[0007] FIGS. **4**A-C show details of a gas injector wherein FIG. **4**A is a perspective view of the injector, FIG. **4**B is a top view of the injector and FIG. **4**C is a side view of the injector.

[0008] FIGS. **5**A-C show details of an annular insert with a bayonet opening wherein FIG. **5**A is a perspective view of the insert, FIG. **5**B is a top view of the insert and FIG. **5**C is a view along line A-A in FIG. **5**B.

[0009] FIGS. **6**A-C show details of an RF shield which surrounds the gas injector wherein FIG. **6**A is a perspective view of the RF shield, FIG. **6**B is a top view of the RF shield, and FIG. **6**C is a side view of the RF shield.

[0010] FIGS. **7**A-D show details of a faceplate which surrounds the RF shield and mounts the gas injector by a twist and lock arrangement into the annular insert wherein FIG. **7**A is a top view of one half of the face plate, FIG. **7**B is a perspective view of the outer side of one half of the faceplate, FIG. **7**C is a perspective view of the inside of one half of the faceplate, and FIG. **7**D is a side view of one half of the faceplate.

DETAILED DESCRIPTION

[0011] The present invention will now be described in detail with reference to a few preferred embodiments thereof as illustrated in the accompanying drawings. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art, that the present invention may be practiced without some or all of these specific details. In other instances, well known process steps and/or structures have not been described in detail in order to not unnecessarily obscure the present invention. As used herein, the term "about" should be construed to include values up to 10% above or below the values recited.

[0012] Described herein is a replaceable window and gas injector assembly of a plasma reaction chamber in which semiconductor substrates can be processed. The window and gas injection assembly are designed to avoid chipping of the window which is typically made of quartz and in prior mounting arrangements the window has a bayonet opening machined therein. Due to the brittle nature of the quartz material, the machined bayonet opening was subject to chipping when the gas injector assembly was inserted into the bayonet opening.

[0013] The replaceable window is made from a dielectric material, such as quartz and has the shape of a disk of uniform thickness. A central recess in the upper surface is configured to receive an annular insert having a bayonet opening and a central bore in the window receives a gas injector having a distal end flush or below the bottom surface of the window to deliver process gas into the chamber. An induction coil (not shown) above the window energizes the process gas into a plasma state for processing the substrate. For example, an etch gas can be supplied by the injector for plasma etching the substrate.

[0014] The gas injector can include one or more gas outlets, a flange which sits on the bottom wall of the central recess is vacuum sealed to the window with an O-ring which fits in a groove on the bottom of the flange. An RF shield surrounds the gas injector and a faceplate surrounds the RF

shield. The faceplate is a two piece part which is bolted together around the RF shield and the faceplate includes protrusions (lugs) to engage the bayonet opening in the insert.

[0015] The insert with the bayonet opening can comprise any material that has a higher tensile strength than quartz such as plastic material. Alternatively, the insert with the bayonet opening can be made of ceramic, metal, silicon carbide, graphite, etc. In a preferred embodiment the insert with the bayonet opening is attached to the window with bolts threaded into TORLON inserts **20***a* (see FIG. **2**C) fitted in mounting holes in the window. However, the insert can have threads which can be screwed into the window or the insert can be bonded to the window.

[0016] FIG. **1** shows details of a window **15** having a gas injection assembly mounted in the center thereof. The gas injection assembly includes a faceplate **19** engaging an insert **17** having a bayonet opening. The gas injection assembly is connected to a gas connection block **21** which receives process gas from supply lines **21***a,* **21***b* and an injector extending through the window delivers the process gas to the chamber for processing a semiconductor wafer.

[0017] Details of a replaceable window and gas injector assembly of an inductively coupled plasma chamber are illustrated in FIGS. **2**A-C. The parts include a quartz window **15**, a gas injector **16**, an annular insert **17** which is secured to the window by bolts **20**, an RF shield **18**, and a faceplate **19**. A shown in FIG. **2**A, the gas injection assembly (the gas injector **16**, the RF shield **18** and the faceplate **19**) is attached to the gas connection block **21**. As described later, the faceplate **19** includes three projections which engage the bayonet opening of the insert **17** in a twist-and-lock fashion.

[0018] FIG. **3**A shows details of the window **15** which includes a central cylindrical recess **15***a* for receipt of the annular insert **17**, and 3 threaded or blind holes **15***b* for receipt of bolts **20** which can be threaded into the window or into threaded inserts fitted in the holes **15***b* to attach the insert **17** to the window **15**. The window includes a central bore **15***c* for receipt of the gas injector **16** and at least one blind hole **15***d* in the upper surface **15***e* for

receipt of a temperature sensor. A clocking feature **15***f* is provided in the bottom outer side surface **15***h* and elongated channels **15***g* are located in the outer side surface **15***h*.

[0019] FIG. **3**B is a bottom view of the window shown in FIG. **3**A, with an area indicated for detail G. The bottom surface **15***i* of the window has an annular vacuum sealing surface **15***j*. The window preferably has an outer diameter of about 20 inches, and the vacuum sealing surface extends about 1 inch in from the outer edge of the window. The clocking feature **15***f* is formed by a recess having a diameter of about 0.4 inch and height of about 0.3 inch.

[0020] FIG. **3**C is a cross section of the window taken along line A-A in Fig. **3**B. The window preferably has a thickness of about 1.75 inch, the channels **15***g* have a width of about 0.6 inch, extend about 1/8th of the circumference of the window and are located in the middle of the side surface **15***h*, the cylindrical recess **15***a* has a diameter of about 3.4 inches and a depth of about 0.5 inch.

[0021] FIG. **3**D is a cross section of the window with areas indicated for views of details H and J, FIG. **3**E is a top view of the window with areas indicated for section line C-C and detail L, and FIG. **3**F is a side view of the window with an area indicated for detail K.

[0022] FIG. **3**G is a view of detail H and shows a cross section of one of the channels **15***g* in the outer surface **15***g* of the window. The channel has a non-uniform depth extending into the outer surface **15***h* such that the depth is a maximum at the midpoint of the channel. As shown in FIG. **3**C, the channel has planar sidewalls which are parallel to the upper and lower surfaces of the window and the sidewalls are connected by a rounded bottom wall. The sidewalls are preferably about 0.6 inch apart and the rounded bottom wall has a radius of curvature of about 0.3 inch. The rounded bottom wall extends rectilinearly between two locations along the outer surface **15***h* such that the channel has a maximum depth of about 0.9 inch at its midpoint. As shown in Fig. **3**E, the bottom walls of the channels on opposite sides of the window are parallel to each other. As shown in FIG.

3E, the blind hole **15***d* is located 45° from the midpoint of one of the channels **15***g*. FIG. **3**H is a view of detail K and shows relative dimensions of the blind hole **15***d* which preferably has a diameter of about 0.22 inch, a depth of about 1.2 inches and a tapered opening with a diameter of about 0.48 inch extending into the upper surface **15***e*.

[0023] FIG. **3**I is a top view of detail G and shows relative dimensions of clocking feature **15***f*. FIG. **3**J is a side view along line B-B in FIG. **3**I. FIG. **3**I shows that the clocking feature **15***f* includes a planar wall parallel to the lower surface of the window and a curved sidewall which preferably has a radius of about 0.6 inch and depth of about 0.3 inch.

[0024] FIG. **3**K shows relative dimensions of the cylindrical recess **15***a* which preferably is a circular recess with a diameter of about 3.4 inches and a depth of about 0.5 inch. The three threaded holes **15***b* are located 120° apart and about 1.25 inches from the center of central bore **5***c*. The threaded holes can have diameters of about 0.4 inch and a depth of about 0.5 inch and can be machined 1/4-32 threaded holes or contain threaded polymer sleeves such as threaded TORLON sleeves to engage the bolts **20**. The central bore **15***c* preferably has a diameter of about 1 inch and depth of about 1.25 inches, upper and lower edges of the central bore being rounded with a radius of curvature of about 0.06 inch. The bottom of the cylindrical recess **15***a* is preferably polished to provide a vacuum sealing surface and upper and lower edges of the recess **15***a* are preferably rounded with a radius of curvature of about 0.02 inch. A blind alignment hole **15***k* is located about 0.9 inch from the center of central bore **15***c* and preferably has a diameter of about 0.09 inch and a depth of about 0.15 inch. FIG. **3**M is an enlarged view of alignment hole **15***k* along line E-E in FIG. **3**L.

[0025] FIG. **4**A shows details of the gas injector **16** which has a group of inner gas outlets **16***a*, a group of outer gas outlets **16***d* and a flange **16***b*, the injector configured such that the end with the outlets **16***a* and **16***d* fits in the central bore **15***c* in the window **15** and the flange **16***b* rests on the bottom of the cylindrical recess **15***a* of the quartz window.

[0026] FIG. **4**B is a bottom view of the gas injector which shows the details of an inner group of gas outlets **16***a* and an outer group of gas outlets **16***d*, the inner and outer outlets supplied the same or different gas at adjustable flow rates. The gas injector **16** has 19 inner gas outlets **16***a* arranged on the distal end of the gas injector **16** in a hexagonal arrangement and the outlets **16***a* are oriented to inject gas axially toward a substrate undergoing processing. Eight outer outlets **16***d* are arranged 45° apart around the side of the injector and inject gas in a conical path towards the substrate. The lower end of the injector has a diameter of about 1 inch and the flange has a clocking feature **16***c*. FIG. **4**C shows the details and dimensions of a side view of the gas injector shown in FIG. **4**A.

[0027] FIG. **5**A shows an annular insert **17** with a three pronged bayonet opening **17***c* which is secured in the cylindrical recess **15***a* of the window **15**. FIG. **5**B shows a top view of the annular insert **17** which has three stepped holes **17***a* which are 120° apart. The insert preferably has an outer diameter of about 3.4 inches and a thickness of about 0.5 inch. The stepped holes **17***a* are preferably about 0.3 inch in diameter at upper portions thereof and about 0.2 inch in diameter at lower portions thereof, with all three stepped holes located on a radius of about 1.3 inches from the center of central bore **17***c*. The stepped holes **17***a* receive bolts which can be threaded into threaded holes in the window or polymer sleeves located in the blind holes **15***b* of the window **15.**

[0028] The annular insert **17** has three inwardly extending protrusions **17***b* that form the bayonet opening. Preferably, each protrusion extends about 58° in a circumferential direction and the space between adjacent protrusions extends about 62° whereby midpoints of the protrusions are spaced 120° apart. The inner surfaces of the protrusions **17***b* lie on a circle having a diameter of about 2 inches. The protrusions **17***b* have a height of about 0.35 inch and extend inwardly about 0.15 inch from the bayonet opening which has a diameter of about 2.3 inches.

[0029] To mount an injector **16** in the window, the insert **17** can be secured in the cylindrical recess **15***a* of the window with bolts engaging threaded inserts in the blind holes **15***b*. Then, an injector **16** with surrounding RF shield **18** and faceplate **19** is inserted such that the lower end of the injector extends through central bore **15***c* and the faceplate **19** is rotated such that three outwardly extending flanges **19***c* on the lower end of the faceplate **19** are engaged in the gaps between the protrusions **17***b* and the upper surface of the window **15**.

[0030] FIG. **6**A is a perspective view of the RF shield **18** which includes a square upper section **18***a*, a pin **18***b*, four threaded holes **18***c*, an O-ring groove **18***d*, four threaded holes **18***c*, a lower cylindrical section **18***e* and an intermediate cylindrical section **18***f*. The four threaded holes **18***c* receive bolts attaching the RF shield **18** to a gas connection block **21** (see FIG. **1**) having two gas lines **21***a*, **21***b* for supplying the inner gas outlets **16***a* and outer gas outlets **16***d* of the injector **16**. The O-ring groove **18***d* receives an O-ring to provide a gas seal between the gas connection block **21** and the RF shield **18**. Another O-ring in the bottom of the gas connection block **21** provides a gas seal between the top of the injector **16** and the gas connection block **21**. The lower cylindrical section **18***e* and the intermediate cylindrical section **18***f* of the RF shield **18** fit over the injector **16** such that and upper part of the pin **18***b* engages a groove on the outer surface of the injector **16** and a lower part of the pin **18***b* fits in the alignment pin hole **15***k*.

[0031] FIG. **6**B is atop view of the RF shield **18** and FIG. **6**C is a side view of the RF shield **18**. The RF shield **18** is preferably made of metal such as copper or aluminum optionally plated with a metal such as silver.

[0032] FIGS. **7**A-D show details of the faceplate **19**. The faceplate **19** includes two halves which bolt together around the RF shield **18** and the bottom of the faceplate includes a twist-and-lock arrangement for securing the injector **16**, RF shield **18** and faceplate **19** in the insert **17**.

[0033] FIGS.**7**A-D show a half section of the faceplate **19** which when attached to the other half section forms a cylindrical inner region **19***a* and a hexagonal outer region **19***b* having three inclined protrusions **19***c* at the

lower end thereof. One half section includes threaded holes **19***d* on the side face **19***f* for receiving bolts extending from the other half section to attach the two half sections together. The side face **19***f* also includes alignment pin holes **19***e* which receive alignment pins extending from the other half section.

[0034] Each half section of the facelate **19** includes three corners **19***g* where four outer surfaces meet at 120°. The bottom of each half section includes a step **19***h* which fits over the lower cylindrical section **18***e* of the RF shield **18**. Gaps **19***i* between the protrusions **19***c* are sized to allow the protrusions **17***b* of the insert **17** to slide along the outside of the faceplate **18** and when the bottom of the faceplate **18** engages the window **15**, the faceplate **19** can be rotated to move the protrusions **19***c* into the gaps **17***c* under the protrusions **17***b*. The faceplate is rotated until the protrusions **19***c* engage the undersides of the protrusions **17***b* and three vertical ribs **19***j* above each protrusion **19***c* provide a frictional fit between the inner surfaces of the protrusions **17***b* and the outer surface of the faceplate **19.**

[0035] FIG. **7**D is a perspective side view of one of the half sections showing the hexagonal outer region **19***b* and one of the protrusions **19***c* which is preferably inclined at an angle of about 4° and three vertical ribs **19***i* are provided above the protrusion **19***c*.

[0036] The annular insert **17**, the RF shield **18** and the faceplate **19** provide an improved mounting system for a gas injector **16** in a dielectric window **15**. The improved mounting system overcomes problems with dielectric windows having bayonet openings for mounting injectors therein which were apt to chip and become damaged due to the brittleness of the window material.

[0037] The annular insert with the bayonet opening fits in a window's cylindrical recess and is adhered to the window with bolts engaging threaded inserts fitted in holes in the recess of the window. Alternatively, the insert can be bonded to the window with a suitable bonding material. Windows with low tensile strengths, such as quartz suffer from chipping when the

bayonet opening is machined into the window. Low tensile strengths in the quartz window chip due to a point load being placed on the window when the gas injector assembly is installed. The insert is preferably made from a material having a higher tensile strength than the window preferably from a plastic such as "ULTEM" but any other suitable material can be used for the insert such as a ceramic, metal, silicon carbide, graphite, etc. The insert constructed from a non-brittle material will eliminate the mounting issues associated with window members chipping when constructed from materials with low tensile yield strengths.

[0038] In a most preferred mounting arrangement, the gas injector with a flange, which has a groove on the bottom for an O-ring, sits on the quartz disk's recess and is vacuum sealed to the window with an O-ring in the groove of the flange to provide a seal between the gas injector and the opening in the window, and an annular insert with a bayonet opening is adhered to the quartz window. In another embodiment the gas injector is mounted in an opening in the window with one or more O-rings between the flange on the gas injector and the quartz window. The gas outlets on the distal of the gas injector are preferably located below or flush with the inner surface of the window. A faceplate with three protrusions (lugs) is inserted into the insert with the bayonet opening and the lugs are hand tightened to hold the injector in place. In a preferred embodiment, an RF shield surrounds the gas injector and the faceplate surrounds the RF shield.

[0039] The gas injector is preferably made from a dielectric material such as quartz. Alternatively, the injector can be made from other material such as aluminum, stainless steel, alumina, silicon nitride, etc. The gas outlets can have any desired shape such as uniform diameter along the entire length thereof or other shape such as conically tapered, flared surfaces or radially contoured surfaces. The gas outlets can be oriented to inject the gas in any direction, including directly at the substrate and/or at an acute angle with respect to the substrate. In a preferred embodiment, 19 axially extending gas outlets are arranged on the distal end of the gas injector in a

hexagonal arrangement and eight non-axially extending gas outlets are located near or on the outer aside wall of the injector.

[0040] The gas injector is thus clamped in place by the faceplate which is inserted into the bayonet opening of the insert. In a most preferred embodiment, the faceplate is hand tightened to the insert by three lugs whereby the faceplate may be inserted in a twist and lock fashion into the bayonet opening of the insert. The outer surface of the faceplate can have a hexagonal shape to allow hand tightening of the faceplate in the bayonet opening of the insert.

[0041] Having disclosed exemplary embodiments and the best mode, modifications and variations may be made to the disclosed embodiments while remaining within the subject and spirit of the invention as defined by the following claims.

WHAT IS CLAIMED IS:

1. A dielectric window of a plasma processing chamber wherein semiconductor substrates are plasma processed and in which an injector assembly comprising a gas injector, RF shield, faceplate and annular insert is mounted in the window to supply process gas into the plasma processing chamber, the window comprising:

a disk having a uniform thickness, a lower vacuum sealing surface on a lower surface thereof adapted to seal against an upper surface of the plasma processing chamber, a central bore configured to receive the gas injector which delivers process gas into the center of the plasma processing chamber, and an upper recess in the upper surface surrounding the central bore and configured to receive the annular insert used to mount the gas injector assembly in the window.

2. The window of claim 1, including a blind hole for receipt of a temperature sensor in the upper surface and a clocking feature on an outer edge of the lower surface.

3. The window of claim 1, including four circumferentially extending channels in an outer periphery thereof, midpoints of the four channels being spaced 90° apart.

4. The window of claim 3, wherein each of the channels has a pair straight walls and a straight bottom wall, the bottom walls of two of the channels being parallel to each other and the bottom walls of the other two channels being parallel to each other.

5. The window of claim 1, wherein the central recess is defined by a cylindrical sidewall and a planar bottom wall, the bottom wall including three vertical mounting holes spaced 120° apart and located midway between the central bore and the sidewall.

6. The window of claim 5, wherein the planar bottom wall is a vacuum sealing surface and includes an alignment hole configured to receive an alignment pin on a lower end of the RF shield.

7. The window of claim 1, wherein the window has a diameter of about 20 inches, a thickness of about 1.75 inches, an annular vacuum sealing surface about 1 inch wide on an outer portion of the lower surface, the central recess has a diameter of about 3.4 inches and a depth of about 0.5 inch, and the central bore has a diameter of about 1 inch.

8. The window of claim 2, wherein the blind hole has a diameter of about 0.22 inch, a depth of about 1.2 inches and a tapered opening with a diameter of about 0.48 inch..

9. The window of claim 5, wherein the mounting holes are located about 1.25 inches from the center of the central bore, each of the mounting holes having a diameter of about 0.4 inch and a depth of about 0.5 inch.

10. The window of claim 6, wherein the alignment hole is located about 0.9 inch from the center of the central bore, has a diameter of about 0.09 inch and a depth of about 0.15 inch.

11. The window of claim 4, wherein each channel has a width of about 0.6 inch, the bottom wall is round with a radius of curvature of about 0.3 inch, and the maximum depth of the channel is 0.9 inch at its midpoint.

12. The window of claim 2, wherein the clocking feature comprises a concave indentation in the outer periphery of the window wherein the indentation having a depth of about 0.3 inch and defined by a planar surface parallel to the lower surface and a curved sidewall extending into the outer periphery and having a radius of curvature of about 0.4 inch.

13. The window of claim 1, wherein the window consists of quartz.

14. An annular insert adapted to fit in a cylindrical recess in an upper surface of a dielectric window of a plasma processing chamber wherein semiconductor substrates are plasma processed and in which an injector assembly comprising a gas injector, RF shield, faceplate and the annular insert is mounted in the window to supply process gas into the plasma processing chamber, the annular insert comprising:

an annular disk having a uniform thickness and adapted to be received in a cylindrical recess in the upper surface of the window, the disk having a cylindrical outer wall, an upper surface, a lower surface, and a bayonet opening extending between the upper and lower surfaces.

15. The insert of claim 14, wherein the bayonet opening includes three inwardly extending protrusions and three gaps separating the protrusions, each of the protrusions extending about 58° and each of the gaps extending about 62°, the protrusions having a thickness of about 0.35 inch.

16. The insert of claim 14, wherein the disk has a diameter of about 3.4 inches and a thickness of about 0.5 inch.

17. The insert of claim 14, wherein the upper surface includes three stepped holes spaced 120° apart and located about 1.3 inches from the center of the bayonet opening, each of the holes having an upper portion with a diameter of about 0.3 inch and a lower portion having a diameter of about 0.2 inch.

18. The insert of claim 14, wherein the insert consists of a polymer material.

FIG. 1

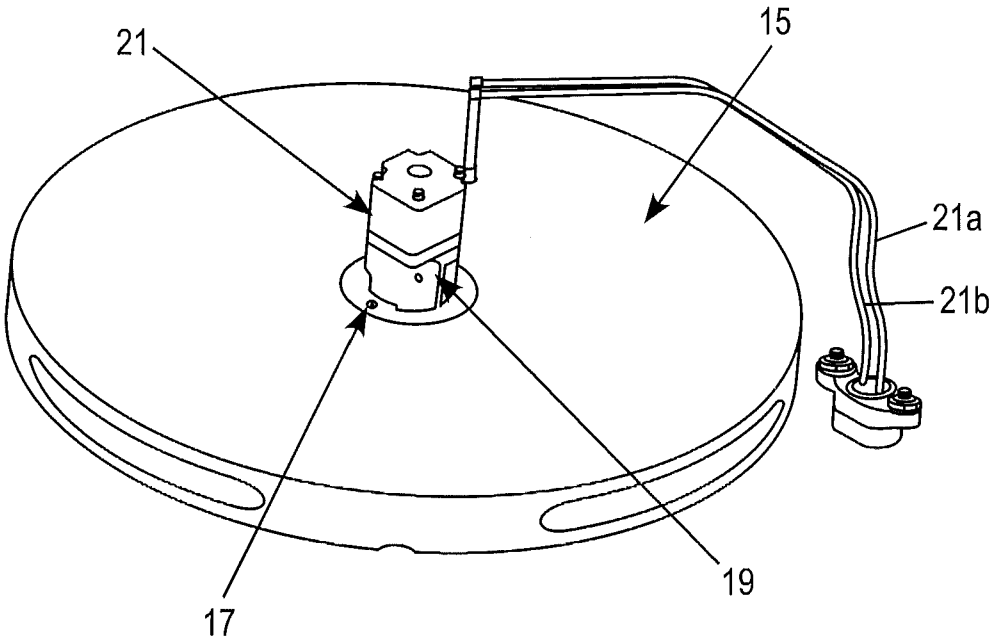


FIG. 2A

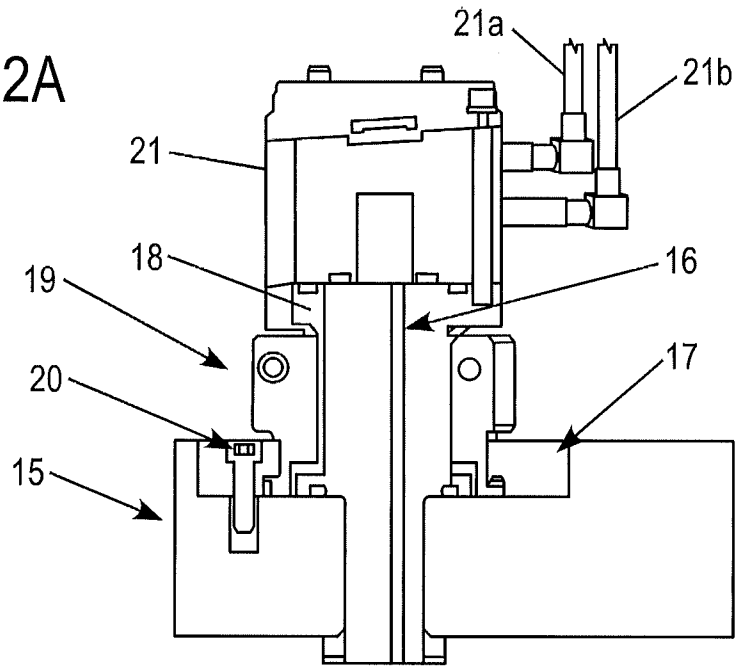


FIG. 2B

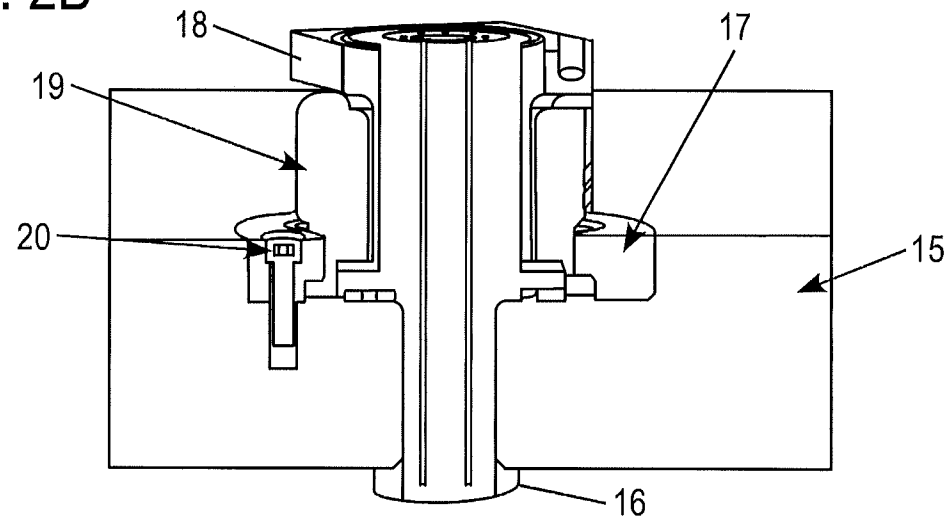


FIG. 2C

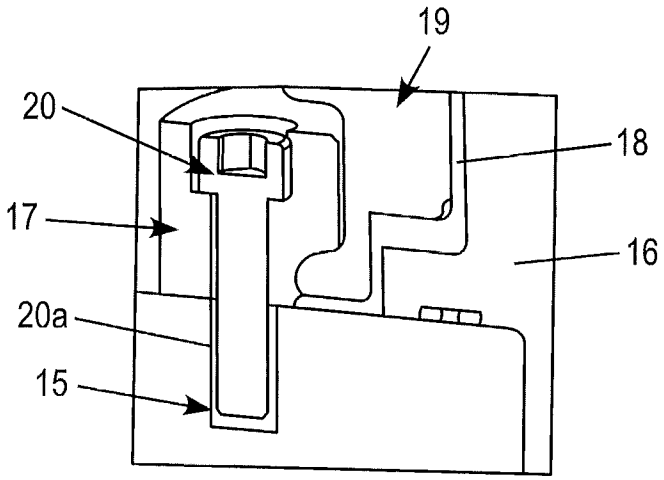


FIG. 3A

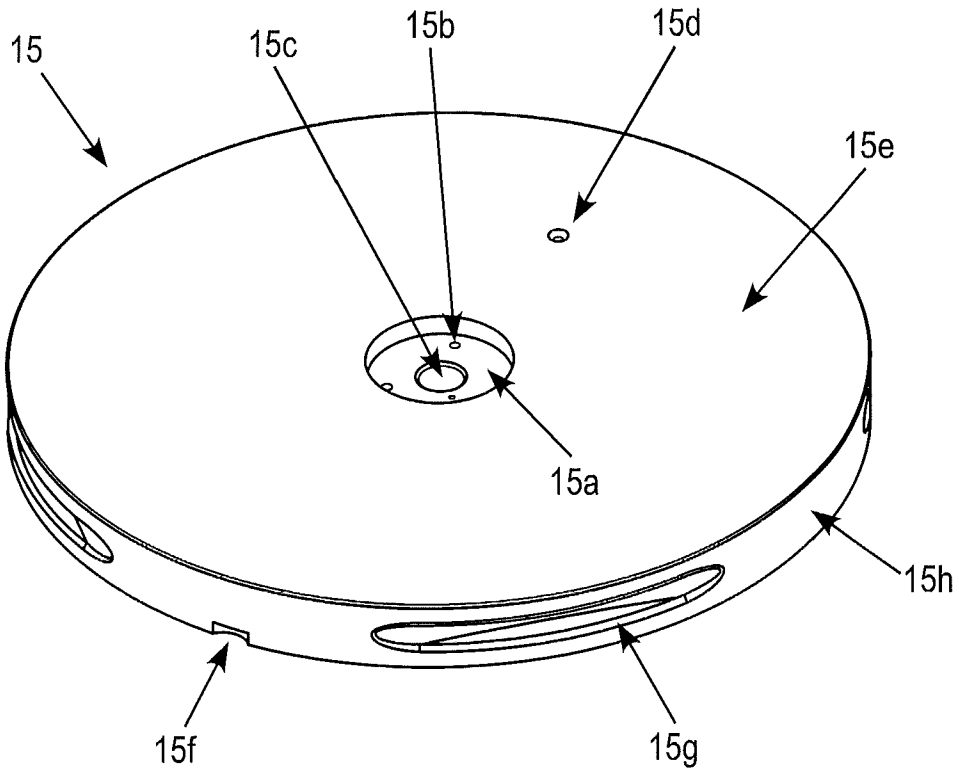
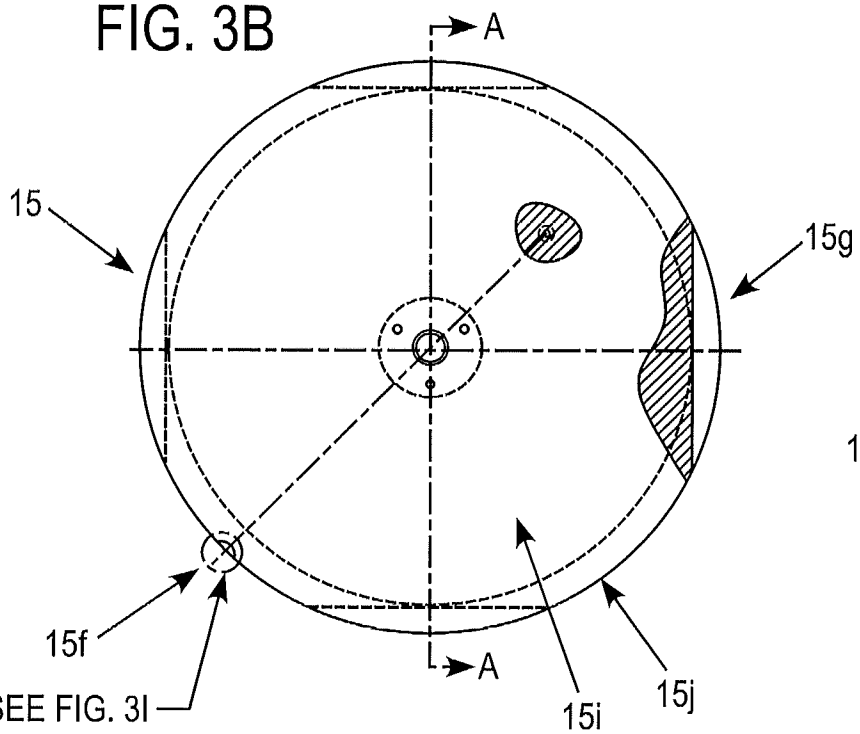


FIG. 3B



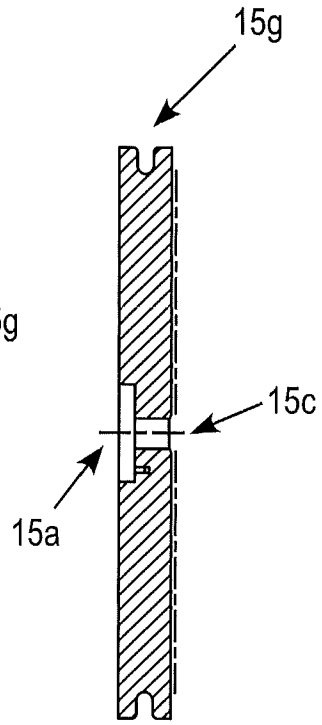


FIG. 3C

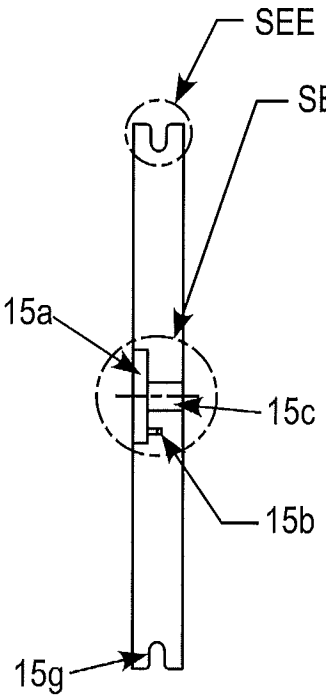


FIG. 3D

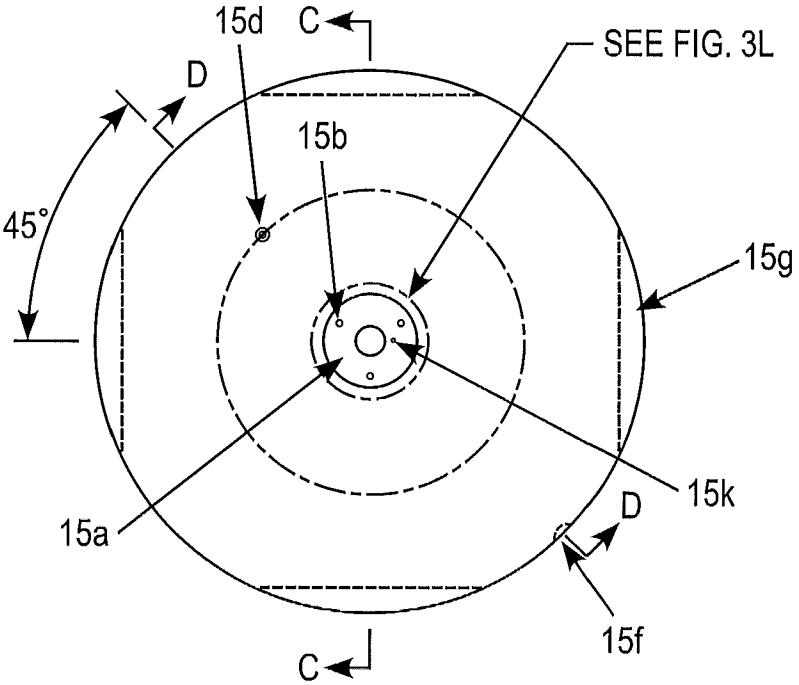


FIG. 3E

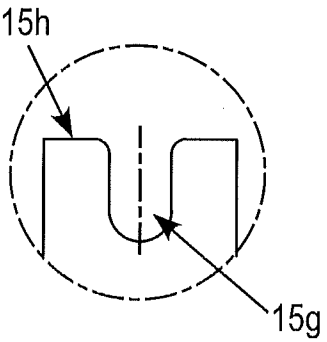


FIG. 3G

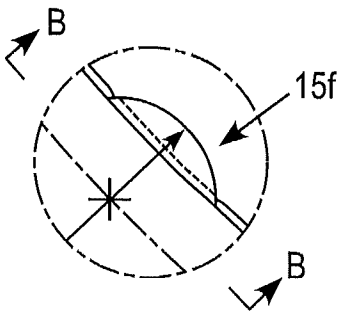


FIG. 3I

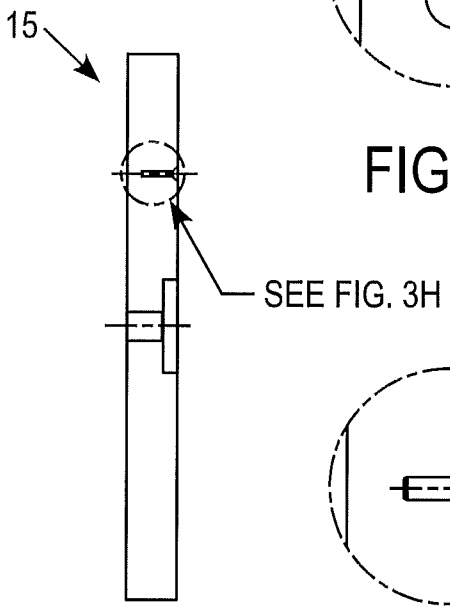


FIG. 3F

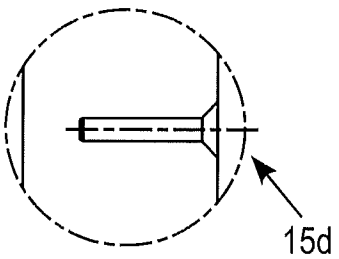


FIG. 3H

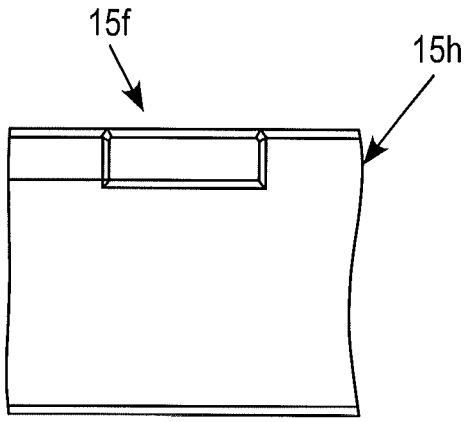
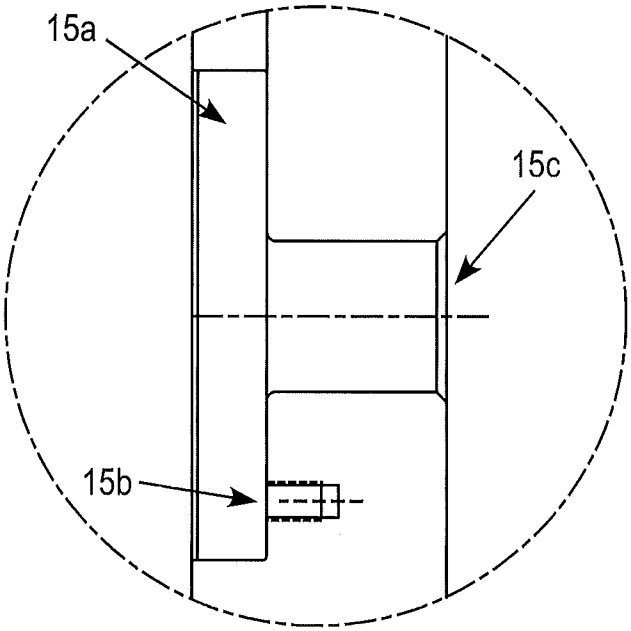


FIG. 3J

FIG. 3K



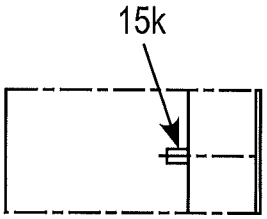


FIG. 3M

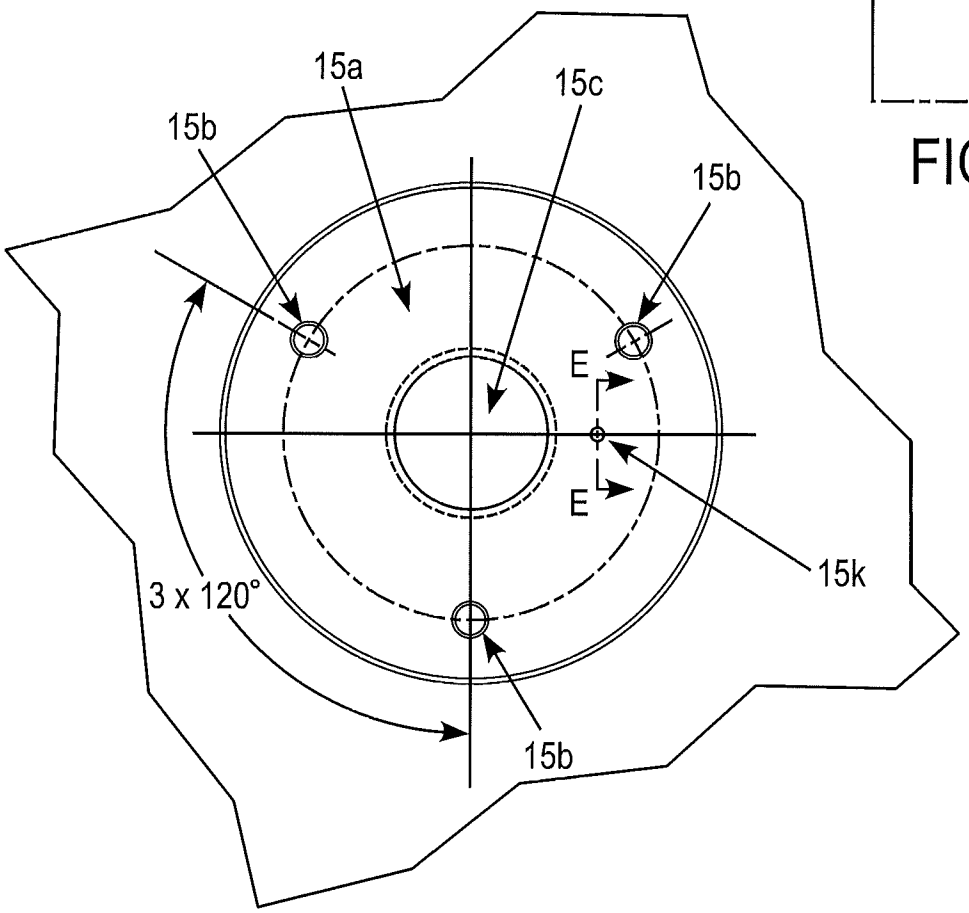


FIG. 3L

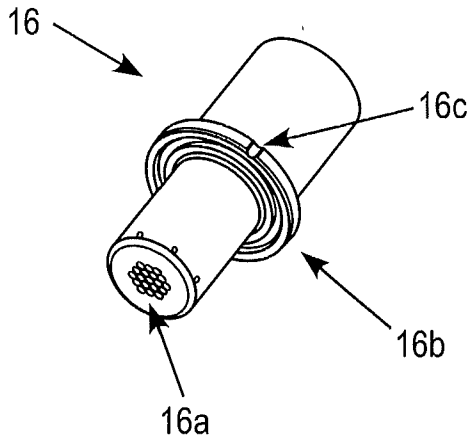


FIG. 4A

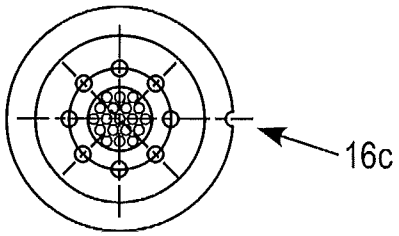


FIG. 4B

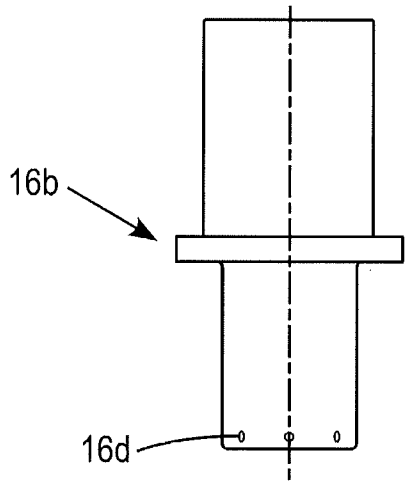


FIG. 4C

FIG. 5A

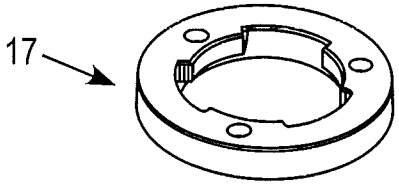


FIG. 5B

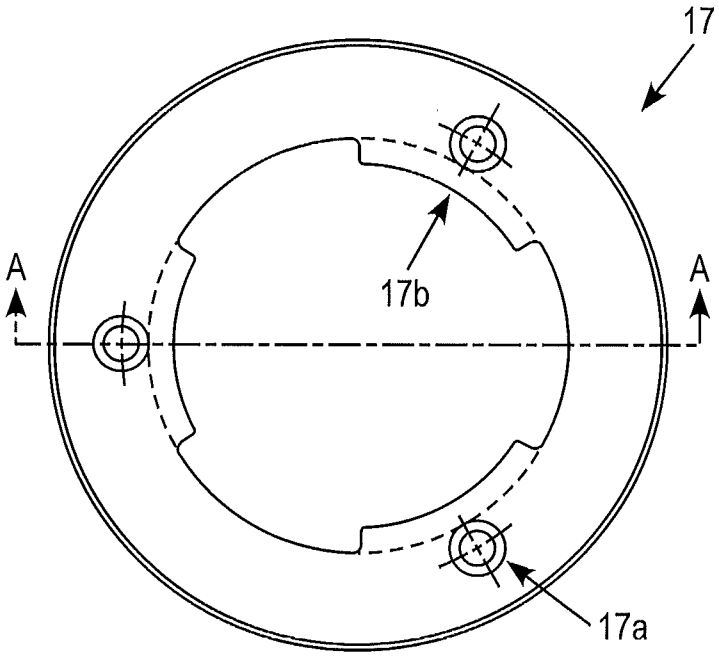
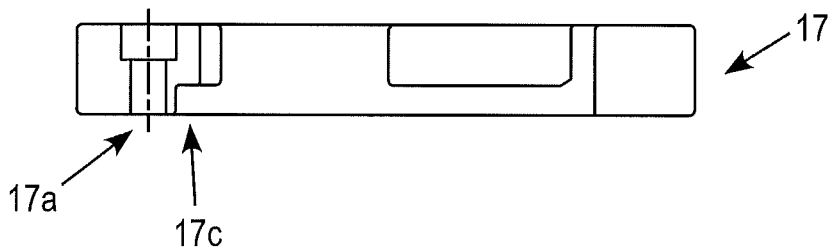


FIG. 5C



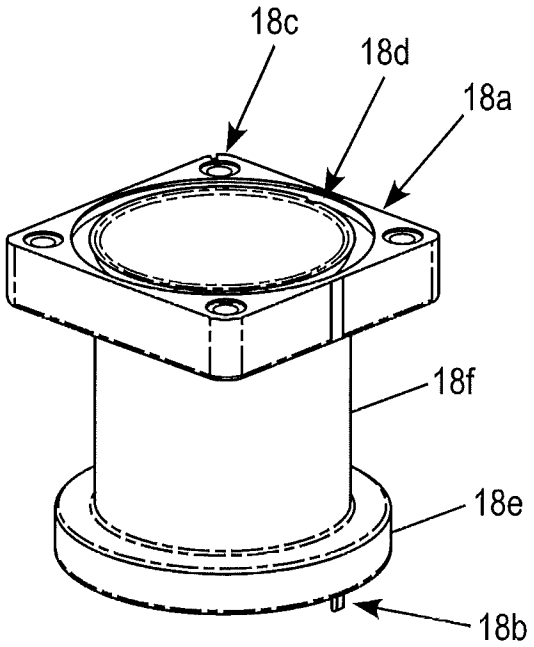


FIG. 6A

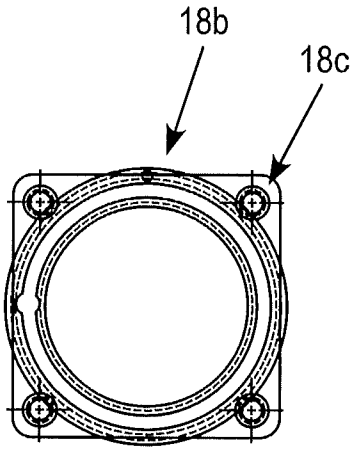


FIG. 6B

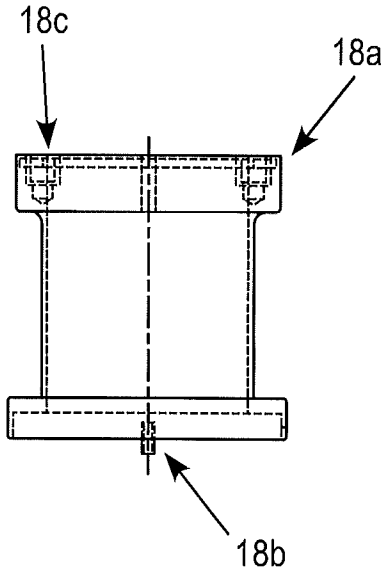


FIG. 6C

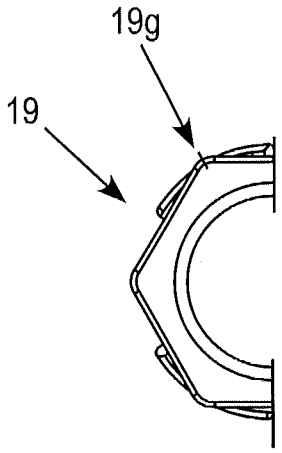


FIG. 7A

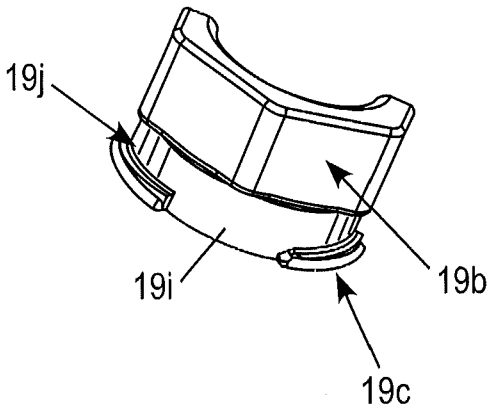


FIG. 7B

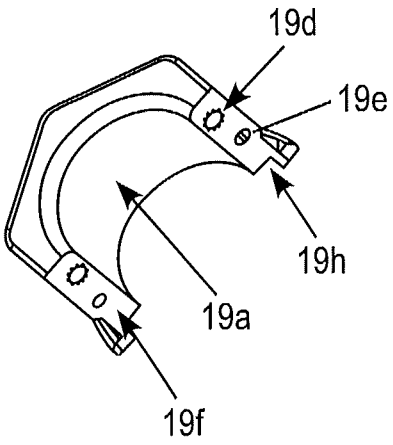
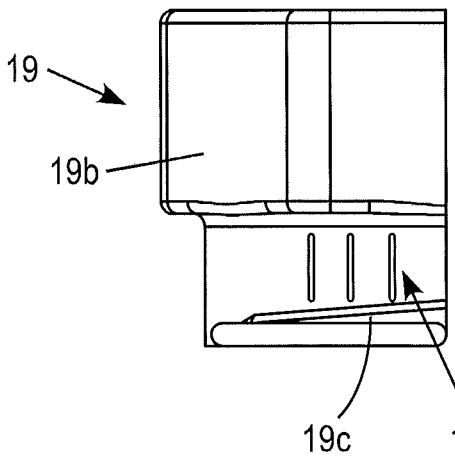


FIG. 7C

FIG. 7D



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/061029

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - C23C 16/455 (2012.01)
USPC - 438/729
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)
IPC(8) - C23C 16/455 (2012.01)
USPC - 118/719, 723AN, 723ER, 733; 156/345.33, 345.48; 438/729, 730, 731

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2001/0010257 A1 (NI et al) 02 August 2001 (02.08.2001) entire document	1-18
A	US 2011/0056626 A1 (BROWN et al) 10 March 2011 (10.03.2011) entire document	1-18
A	US 5,824,605 A (CHEN et al) 20 October 1998 (20.10.1998) entire document	1-18
A	US 2003/0070620 A1 (COOPERBERG et al) 17 April 2003 (17.04.2003) entire document	1-18

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

* 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 another 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	Date of mailing of the international search report
20 December 2012	02 JAN 2013
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)