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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 September 2016 (01.09.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/137946 A1

(51) International Patent Classification:
C23C 16/46 (2006.01) *H01L 21/687* (2006.01)
C23C 16/458 (2006.01)

(21) International Application Number:
PCT/US2016/019063

(22) International Filing Date:
23 February 2016 (23.02.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/119,476 23 February 2015 (23.02.2015) US

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(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, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, 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, SA, 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, ST, 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,

[Continued on next page]

(54) Title: ELECTRICAL CONNECTION WITH PROTECTION FROM HARSH ENVIRONMENTS

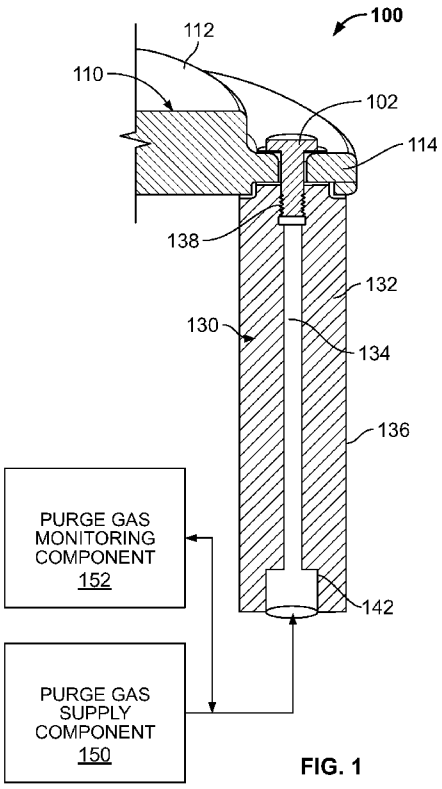


FIG. 1

(57) Abstract: A heater assembly is shown and described herein. The heater assembly may comprise a heating element and a removable post. The post is electrically connected with the heating element. Electrical contacts of the post and heating element are protected from an external atmosphere to avoid or reduce corrosion of the electrical contacts. The post can include a hollow core or internal-post. The internal-post can be supplied with a purge gas. When the post and the heating element are connected, gaskets can provide seals that separate the electrical contacts from the external atmosphere.

WO 2016/137946 A1

SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

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

TITLE

ELECTRICAL CONNECTION WITH PROTECTION FROM HARSH ENVIRONMENTS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Application No. 62/119,476 entitled "ELECTRICAL CONNECTION WITH PROTECTION FROM HARSH ENVIRONMENTS," filed on February 23, 2015, which is hereby incorporated by reference in its entirety.

FIELD OF INVENTION

[0002] The present invention relates to a heating assembly and, more particularly, to a ceramic heater made of a pyrolytic boron nitride on a graphite or pyrolytic graphite.

BACKGROUND

[0003] Heaters and electrostatic chucks are used in a number of system applications such as molecular beam epitaxy, space experiments, substrate heaters for electron microscopy and in the growth of superconducting films, etc. Heaters can be used to heat semiconductor wafers in the manufacture of semiconductors. The heater is typically in a confined environment of a processing vessel. Generally, the environment has a relatively high temperature and a highly corrosive atmosphere. Traditional heaters often consist of a heating platen formed of a sintered ceramic body with an embedded metal wire operating as a resistive element when electricity or power is supplied.

[0004] Some heaters utilize pyrolytic boron nitride (PBN). Pyrolytic boron nitride is formed by chemical vapor deposition of boron nitride in a reactor chamber by the vapor phase reaction of ammonia and a boron containing gas such as boron trichloride (BCl_3). The pyrolytic boron nitride is of very high purity and, when separated or released from the substrate, forms a self-standing article of purified pyrolytic boron nitride. In other cases, the pyrolytic boron nitride coating can be made to adhere to the substrate to form a coated article.

[0005] Traditional heaters typically include a dielectric base of boron nitride and a heating element formed from a conductive material capable of resistive heating such as graphite and more particularly pyrolytic graphite. The heating element is connected to an external power supply to form a resistive heater. In certain applications such as in the growth of superconducting films, it is necessary to introduce oxygen into the atmosphere of the reacting chamber in which

the superconducting film is grown. The oxygen in the atmosphere will react with any exposed graphite conductor in the heating unit to oxidize the conductor causing an open circuit. In other applications, electrically conductive coatings may be deposited on the surface of the heater, which can create an electrical ground fault or short circuit when the coating is in contact with the exposed conductor.

[0006] Certain materials have preferred electrical properties and cost advantages for use as electrical heating elements but may suffer from corrosive attack in the application. To mitigate this, the conductive element can be coated with a material that is inert to the environment, but such coatings can be electrically insulating. To make electrical connection to the conductor, it must be exposed at some points, without the inert protective coating.

[0007] U.S. Pat. No. 5,343,022 describes a pyrolytic heating element in which multiple graphite post (or shaft) connectors are used. The shafts have internal tapped holes for attachment to an external power supply. The assembled heating element and shafts are then coated with a pyrolytic boron nitride layer to encapsulate the conductor and shafts to isolate the graphite from the process chemistry prior to adding the last capping layer of dielectric pyrolytic boron nitride. Thus, the posts are integrally bonded to the heater, making a single unit, such that the posts and bolts are fastened to the heater as extensions for the power connection. The hot conductor is no longer exposed after the final coating. However, the single assembly generally does not allow for maintenance or repair, without additional and costly coating.

[0008] Furthermore, with multiple electrical leads in separate posts, the mechanical connection around the leads tends to increase stress in thermal expansion during operation thus often breaking the heating element or the leads. In some applications, the thermal stress of the installation can cause an arc at the point of electrical contact with the heating element, which will damage the heating unit and render it nonfunctional.

SUMMARY

[0009] The following presents a summary of this disclosure to provide a basic understanding of some aspects. This summary is intended to neither identify key or critical elements nor define any limitations of embodiments or claims. Furthermore, this summary may provide a simplified overview of some aspects that may be described in greater detail in other portions of this disclosure.

[0010] Described herein is a heater assembly that can generate thermal energy and enables local exposure of a conductor for electrical contact, yet protects the contact area from the harsh environment. The heater assembly can include a heating element and a post that is in electrical communication with the heater element. A surface of the post can include a protective coating comprising a dielectric material. An electrical contact of the post is exposed or not

coated with the protective coating. The electrical contact can be electrically connected to a contact of a heating element. A seal can be formed to protect or separate the electrical contacts from an external environment.

[0011] The seal can include a bolt that secures the post to the heating element. Washers can be placed between the heating element and the post to provide a sealed connection. The post can include a hollow center. The hollow center can be provided with a purge gas. Pressure and flow rate of the purge gas can be monitored to determine if the heater assembly is properly functioning. If the heater assembly is not properly functioning, then the post may be detached from the heater assembly for service or replacement.

[0012] The following description and the drawings disclose various illustrative aspects. Some improvements and novel aspects may be expressly identified, while others may be apparent from the description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The accompanying drawings illustrate various systems, apparatuses, devices and related methods, in which like reference characters refer to like parts throughout, and in which:

[0014] FIGURE 1 illustrates a partial cross-sectional view of a heater assembly in accordance with an embodiment of the present disclosure;

[0015] FIGURE 2 illustrates a partial cross-sectional view of a heater assembly including an outer plenum in accordance with an embodiment of the present disclosure;

[0016] FIGURE 3 illustrates a partial cross-sectional view of a heater assembly including a purge gas path in fluid communication with an outer plenum in accordance with an embodiment of the present disclosure;

[0017] FIGURE 4 illustrates a perspective partial cross-sectional view of the heater assembly including the purge gas path in fluid communication with the outer plenum in accordance with an embodiment of the present disclosure;

[0018] FIGURE 5 illustrates a perspective view of the heater assembly including a plurality of posts in accordance with an embodiment of the present disclosure;

[0019] FIGURE 6 illustrates a cross-sectional view of the heater assembly including a plurality of posts in accordance with an embodiment of the present disclosure;

[0020] FIGURE 7 illustrates a cross-sectional view of a connection of a heating element and post in accordance with an embodiment of the present disclosure;

[0021] FIGURE 8A illustrates a perspective view of a circular heating element in accordance with various embodiments herein;

[0022] FIGURE 8B illustrates a perspective view of a circular heating element including tabs in accordance with various embodiments herein; and

[0023] FIGURE 8C illustrates a perspective view of a rectangular heating element in accordance with various embodiments herein.

DETAILED DESCRIPTION

[0024] Reference will now be made to exemplary embodiments, examples of which are illustrated in the accompanying drawings. It is to be understood that other embodiments may be utilized and structural and functional changes may be made. Moreover, features of the various embodiments may be combined or altered. As such, the following description is presented by way of illustration only and should not limit in any way the various alternatives and modifications that may be made to the illustrated embodiments. In this disclosure, numerous specific details provide a thorough understanding of the subject disclosure. It should be understood that aspects of this disclosure may be practiced with other embodiments not necessarily including all aspects described herein, etc.

[0025] As used herein, the words "example" and "exemplary" mean an instance, or illustration. The words "example" or "exemplary" do not indicate a key or preferred aspect or embodiment. The word "or" is intended to be inclusive rather than exclusive, unless context suggests otherwise. As an example, the phrase "A employs B or C," includes any inclusive permutation (e.g., A employs B; A employs C; or A employs both B and C). As another matter, the articles "a" and "an" are generally intended to mean "one or more" unless context suggest otherwise.

[0026] As used herein, the term "heater assembly" refers to a thermal heating device comprising a heating element that produces heat when supplied with a power source. A heater or heater assembly can include, but is not limited to, ceramic heaters, wafer processing devices, or the likes. Furthermore, various embodiments may refer to a threaded member, such as a bolt or screw. However, it is noted that various other means for connection can be utilized, such as pins, latches, or the likes.

[0027] In another aspect, a "protective coating layer," "protective film coating layer," "coating layer," "coating film," "protective layer," or "protective coating layer," or the likes can be used interchangeably, unless context suggests otherwise or warrants a particular distinction among such terms. The terms can indicate the presence of at least one layer or a plurality of layers for coating the part. For instance, a protective coating layer may include a plurality of layers that may or may not comprise different materials.

[0028] Various described embodiments may be utilized in different applications. For instance, a heater assembly may be utilized for heating and/or holding wafer substrates in a plasma chamber or crucible. One or more of the applications may require embodiments to be

utilized in corrosive environments. The corrosive environments may harm or corrode electrical contacts. The electrical contacts are needed to supply power to the heater element.

[0029] Various embodiments described herein relate to a heater assembly that can generate thermal energy and enables local exposure of a conductor for electrical contact, yet protects the contact area from the harsh environment. The heater assembly can comprise a base plate and/or heating element. The base plate can include a platform that can comprise a graphite substrate. The base plate can also include a heating element that can comprise a restive material that generates heat when current is applied to the heating element. The heating element may include a material such as pyrolytic boron nitride and aluminum nitride or aluminum nitride. The material may be coated on the heating element and/or etched in the heating element.

[0030] Current can be applied to the heating element via an electrical connection to a power source. The electrical connection can be achieved via a shaft extending from or attached to the heating element. The shaft can be removable or detachable from the assembly, such that the shaft can be replaced, repaired, or the likes. The shaft can electrically couple the heating element to a power source. In another aspect, the shaft can include a graphite substance electrically connected to the heating element. The post may be at least partially coated with a pyrolytic boron nitride or a suitable dielectric material, while an electrical contact of the post is exposed or not coated with the pyrolytic boron nitride. The electrical contact can be removed from an atmospheric environment via a sealed connection. The sealed connection can include at least one threaded member (e.g., bolt, screw, etc.) that secures the bolt to the base plate. The sealed connection can also include at least one washer. The washer may comprise a flexible material, such as flexible graphite.

[0031] The post may include a hollow internal-post or chamber. The hollow internal-post may include a purge gas, such as an inert gas. The purge gas may include, but is not limited to, nitrogen, argon, helium, or the likes. In an aspect, the heater assembly can include a means to monitor parameters of the purge gas within the hollow internal-post, such as a pressure in the hollow internal-post and/or a means to monitor the flow rate of purge gas in the hollow internal-post. If the pressure in the hollow internal-post and/or the flow rate of purge gas in the hollow internal-post alters, then the post can be removed for repair or inspection.

[0032] FIGURE 1 illustrates a partial cross-sectional view of a heater assembly 100 in accordance with aspects and embodiments of this disclosure. Heater assembly 100 can primarily comprise a heating element 110 and a post 130. The heating element 110 may comprise a graphite material and a borne nitride material. In an example, an outer surface 112 of the heating element 110 may comprise a pyrolytic boron nitride or other material such as aluminum nitride (AlN), aluminum oxide, aluminum oxynitride, silicon nitride, silicon oxide, quartz, glass, or

complexes thereof. In another embodiment, the outer surface 112 may comprise a multi-layer of multiple coatings of the same material, e.g., AIN, AlON, Al_2O_3, etc., or multiple different layers of AlN, AlON, PBN, SiN, etc., coated in succession. In yet another embodiment, the graphite part is first coated with pyrolytic graphite, followed by a coating of protective coating, another layer of pyrolytic graphite coating, to be subsequently followed by another protective coating, coated in succession. The heating element 110 can include a core 114 that may comprise a conductive material, such as a graphite material (e.g., pyrolytic graphite), conductive ceramic, conductive metal, or the like. It is noted that an electrical series circuit may be formed within the heating element 110, such as to connect various power supplies and/or ground connections.

[0033] The heating element 110 may be attached to the post 130. Post 130 can comprise a graphite connector in the form of a post or a tube. A hollow internal-post 134 can be disposed within a base material 132. Base material can comprise an electrically conductive material, such as a graphite (e.g., pyrolytic graphite), metal, or ceramic. While embodiments may describe a conductive base material 132, it is noted that a conductive material may be suspended, enclosed, encased, or otherwise disposed within another material. For instance, embodiments may include a wire, flexible circuit board, or other conductive path disposed within a non-conductive core. It is noted that, at least for the sake of brevity, embodiments refer to a conductive base material 132.

[0034] An external surface of the post 130 may comprise a protective layer 136. As described herein, protective layer 136 can include one or more of pyrolytic boron nitride or other material such as aluminum nitride, aluminum oxide, aluminum oxynitride, silicon nitride, silicon oxide, quartz, glass, or complexes thereof. It is noted that post 130 may include other components not shown for readability, such as a support rod that may be disposed within the hollow internal-post 134 to provide structural integrity.

[0035] While post 130 and hollow internal-post 134 are depicted as generally cylindrical, it is noted that the post 130 and hollow internal-post 134 can comprise different shapes. It is also noted that hollow internal-post 134 may be disposed generally in a center of post 130 or may be disposed in another portion of post 130. Likewise, while hollow internal-post 134 is depicted as running along a length of post 130 from an end proximal to heating element 110 to an opening 142, it is noted that opening 142 may be disposed along another portion of post 130. For instance, opening 142 may be disposed at an outer wall of post 130. In another aspect, post 130 is depicted as connecting to a bottom of heating element 110, however, it is noted that post 130 may connect to a top of heating element 130. Furthermore, post 130 may connect to heating element 110 at various angles.

[0036] In embodiments, the post 130 can include a threaded member 102 comprising a graphite material. The threaded member 102 may be at least partially coated with a protective layer, such as pyrolytic boron nitride or the likes. The threaded member 102 may secure post 130 to heating element 110 as it is inserted to an aperture of heating element 110 and a threaded receiving member 138 of post 130. The threaded member 102 may be at least partially coated with a protective layer. The protective layer may isolate electrical connections and/or protect the electrical connections from corrosive environments. As noted herein, heater assembly 100 may include other means of connection then threaded member 102. In another aspect, heater assembly 100 may additionally or alternatively include a portion of post 130 (or another post), that extends above heating element 110, such as in place of threaded member 102. The other post may be generally coaxial with post 130 and may extend in an opposite direction relative to post 130. It is noted that embodiments without threaded member 102 may utilize gaskets or sealing mechanisms as described herein.

[0037] Hollow internal-post 134 may comprise a purge gas. The purge gas may be provided via a purge gas supply component 150. The purge gas supply component 150 can comprise a reservoir of purge gas that can be fed or pumped into the hollow internal-post 134. In at least one embodiment, purge gas supply component 150 may pump the purge gas into hollow internal-post 134 and/or may allow purge gas to flow into the hollow internal-post 134 as the reservoir may include pressurized purge gas. The purge gas can include inert elements or gasses, such as nitrogen, helium, argon, or the likes. Further, the purge gas may include a mixture of gasses or elements. In an aspect, the purge gas may be chosen based on a desired application and/or monetary costs of the purge gas. For instance, nitrogen may provide an inexpensive purge gas, while helium may allow for increased heat transfer and argon may allow for decreased heat transfer. It is noted that some embodiments may comprise a sealed chamber of purge gas when the post 130 and heating element 110 are connected. Thus, a purge gas supply may be contained within the sealed chamber. In such embodiments, the pressure within the sealed chamber may be monitored, such as by a pressure sensor.

[0038] According to one or more embodiments, the purge gas pressure may be maintained at a desired level or range. For instance, the pressure may be greater than an external or environmental pressure. This may generally prevent potentially corrosive or damaging fumes from entering the post and/or contacting electrical contacts if there is a leak in the heater assembly 100. In other embodiments, the purge gas pressure may be generally equal to or lesser than the environmental pressure.

[0039] As described above, the respective components such as, for example, the heating element, post, and connecting member may be formed from a conductive material, e.g., a

graphite material, and comprise a protective coating layer. It is noted that the conductive materials may include pyrolytic graphite, conductive ceramics, conductive metals, or other conductive material. The coating layer of the graphite component can be chosen as desired and, in embodiments is chosen from a nitride, carbide, carbonitride, or oxynitride of elements selected from a group consisting of B, Al, Si, Ga, refractory hard metals, transition metals, and rare earth metals, or complexes and/or combinations thereof. Examples of suitable materials include, but are not limited to, pyrolytic boron nitride, aluminum nitride, titanium aluminum nitride, titanium nitride, titanium aluminum carbonitride, titanium carbide, silicon carbide, boride, silicide, and silicon nitride.

[0040] In an embodiment, the coating layer comprises pBN. In another embodiment, the layer comprises AlN. In still another embodiment, the coating comprises a complex of AlN and BN. In still yet another embodiment, the coating layer comprises a composition of pyrolytic boron nitride (PBN) and a carbon dopant in an amount of less than about 3 wt % such that its electrical resistivity is smaller than 1014 Ω-cm. In yet a further embodiment, the coating layer comprises an aluminum nitride wherein a small amount of Y_2O_3 is added, e.g. in amount of 5 wt % relative to 100 wt % of aluminum nitride. Both pBN and AlN have excellent insulating and conducting properties and can be easily deposited from the gaseous phase. They also have a high temperature stability. Additionally, they have a different color (white) than the pyrolytic graphite base (black) such that in the step of forming the electrical patterns, the coating layer can be easily visually distinguished from the patterns.

[0041] The thickness of the coating can be selected as desired. In one embodiment, the coating layer has a thickness of about 0.005 to about 0.10 inches (about 0.01 cm to about 0.25 cm); about 0.01 to about 0.05 inches (about 0.025 cm to about 0.1 cm); even about 0.01 to about 0.03 inches (about 0.025 cm to about 0.075 cm). In one embodiment, the coating is less than about 0.02 inches (about 0.05 cm). Here, as elsewhere in the specification and claims, numerical values may be combined to form new and non-disclosed ranges.

[0042] The coating layers may be applied to the respective components by any suitable method for forming, such coating method includes, but is not limited to, physical vapor deposition, chemical vapor deposition, thermal injection methods, thermal spray processes, etc.

[0043] In embodiments, a purge gas monitoring component 152 can comprise means for monitoring parameters of the purge gas, such as a pressure, temperature, chemical make up, and/or an amount of purge gas supplied to the hollow internal-post 134. The means for monitoring the parameters may include pressure sensors, temperature sensors, infrared gas analyzers (which may be utilized to monitor chemical changes due to leaks), gas chromatography devices, meters, dials, or the like. For instance, the means for monitoring may

include means for monitoring pressure including mechanical means (e.g., meters), electrical means, such as a non-transitory processor coupled to a memory, combinations thereof (e.g., pressure sensor in communication with a processor), or the like. In an example, if an amount of purge gas supplied to the hollow internal-post 134 alters or if the pressure in the hollow internal-post 134 alters, then there may be a leak and/or a blockage in the heater assembly 100. The post 130 may be removed or disconnected from the heating element 110 for service and/or replacement. In another example, a chemical composition within the hollow internal-post 134 and or a plume may be monitored. If the composition changes to indicate that the purge gas is diluted or contaminated, then a user may be altered to a leak or other damage to the post, such as melting or burning of components.

[0044] In an aspect, the purge gas monitoring component 152 may comprise one or more human interfaces that may convey information to a user. For instance, an interface may include a dial, screen (e.g., LCD screen), light (e.g. LED light), speaker, or the like. It is noted that the interface may be local to the purge gas monitoring component 152 and/or in remote communication with the purge gas monitoring component 152, such as connected via a communications network. In embodiments, the interface component may display parameters associated with the purge gas (e.g., pressure, flow rate, temperature, etc.). In another aspect, the interface component may initiate an alert or warning if parameters fall below a threshold level and/or experience a threshold amount of change (e.g., sudden fluctuation in pressure, flow rate, etc.). For example, a dial may include a needle that indicates a pressure based on one or more indicia. A portion of the indicia may include warning markings or colorings that indicate the pressure is below a threshold if the needle points at the warning. In another example, the purge gas monitoring component 152 may include one or more LED lights. The LED lights may be activated or deactivated to alert or communicate with a user. For instance, the LED lights may emit a red light, green light, and/or yellow light. Each of these lights may represent a state, such as within an acceptable range, outside of an acceptable range, and/or within a warning range. It is noted that various other interfaces and/or methods of communicating states are within the scope and spirit of this disclosure.

[0045] In some traditional heaters, posts were connected to a heating element and the entire assembly was coated with a protective layer. Thus, if the post failed then the entire heater is rendered inoperable or is otherwise damaged. Various embodiments herein allow for replacement and/or repair of a post or heating element. In another aspect, various embodiments disclosed herein may decrease waste, decrease an amount of pyrolytic boron nitride, cost of construction/maintenance, or the likes.

[0046] FIGURE 2 illustrates a partial cross-sectional view of a heater assembly 200. The partial cross-sectional view can comprise a portion of a heating assembly where a post 230 connects or attaches to a heating element 210. While not shown, a threaded member may be inserted into aperture 212 of heating element 210 and threaded member receiving portion 238 of post 230. The threaded member may be tightened to securely attach the post 230 and the heating element 210 to each other. It is noted that post 230 may connect or attach to heating element 210 by various mechanisms, such as clamps, clips, channel locks, electrostatic force, spring clips, friction-fit connections, fasteners (e.g., screws, bolts, etc.), magnets, and the like.

[0047] Heater assembly 200 can comprise one or more washers or gaskets. For instance, heater assembly 200 can comprise a first seal gasket 252, a second seal gasket 254, and a power gasket 256. The gaskets may comprise a flexible graphite. Flexible graphite can include a soft sheet formed of compressed graphite made from exfoliated mineral flake (crystalline) graphite, such as GRAFOIL. For instance, particles of graphite can be intercalated in an acid solution and exfoliated.

[0048] It is noted that other materials can be utilized for the gaskets such as elastomers, mica, and the likes. The material may be chosen for a desired application, such as based on a level of heat. However, in at least one embodiment, the power gasket 256 comprises an electrically conductive material. For instance, the power gasket 256 may comprise flexible graphite and at least one of the first seal gasket 252 or the second seal gasket 254 can comprise a different material, such as mica. While embodiments may describe a gasket, it is noted that a single gasket may be replaced with a different number of gaskets. For example, power gasket 256 may comprise a plurality of gaskets. In another example, heater assembly 200 may not comprise a threaded member as shown in FIGURE 3. For instance, a terminal end of post 230 may comprise a threaded member, and the heating element 210 can comprise a receiving member that can receive the threaded member of post 230. In such an embodiment, the second seal gasket 256 may not be included. In another embodiment, a threaded member may be sealed (e.g., coated) via a protective layer of pyrolytic boron nitride such that the second seal gasket 254 is not needed. However, for sake of brevity, embodiments herein are described with three gaskets, each of which comprises a flexible graphite material.

[0049] When a threaded member (e.g., threaded member 102) is inserted and/or secures heating element 210 with post 230, a seal can be formed. The seal may comprise various layers. For instance, a first seal may be formed via first seal gasket 252. The heating element 210 and post 230 provide force and/or compress first seal gasket 252 to provide a seal of an inner atmosphere or gas purge path from an outside atmosphere. For instance, purge gas can be provided in hollow internal-post 234. An outer chamber or plenum 258 can be fluidly connected

to the hollow internal-post 234, such as through an aperture 244. Outer plenum 258 may be pressurized with a purge gas (e.g., nitrogen, etc.). Aperture 244 may be a machined hole in the hollow internal-post 234. It is noted that other embodiments can comprise different means for fluidly connecting an outer plenum with a supply of purge gas.

[0050] For instance, FIGURE 3 illustrates a partial cross-sectional view of a heater assembly 300 that can comprise a gas purge path 344 that connects an outer plenum 358 with a hollow inner-post 334. As depicted, gas purge path 344 may be disposed proximal to a threaded member receiving portion of post 330. It is further noted that, while shown as being at different levels or on different planes, the power gasket 256 and first seal gasket 252 may be coplanar, generally parallel, not parallel, or otherwise disposed. In another aspect, power gasket 256 may be below (relative to the orientation shown in FIG. 3) first seal gasket 252. For example, post 230 may comprise a female or recessed portion sized and shaped to receive a male or protruding portion of heating element 210.

[0051] Turning to FIGURE 4, with reference to FIGURE 2, illustrated is a perspective partial cross-sectional view of the heater assembly 200. As depicted, post 230 can comprise a protective coating 236 that can protect post 230 from an external atmosphere 204. The power gasket 256 can provide an electrical connection between exposed electrical contacts of heating element 210 and post 230. The first seal gasket 252 or the second seal gasket 254 may be attacked or corroded by a corrosive atmosphere. Thus, the power gasket 256 and/or the electrical contacts may be at risk of corrosion. In an aspect, the outer plenum 258 may provide purge gas to prevent or decrease corrosion as a failing seal gasket allows a corrosive atmosphere to enter the outer plenum 258. In another aspect, the flow rate of purge gas or pressure in the hollow internal-post 234 and/or outer plenum 258 can be monitored (e.g., via purge gas supply monitoring component 152). If the pressure and/or flow rate of purge gas reaches a threshold level, one or more of the first seal gasket 252 or second seal gasket 254 may have failed. Thus, a user may be alerted (e.g. via purge gas supply monitoring component 152) and the heater assembly 200 may be serviced. It is noted that the pressure and/or flow of purge gas may be altered due to other causes, such as physical damage to the post 230, heating element 210, or a threaded member. An inspection of the heater assembly 200 may be accomplished by removing the post 230.

[0052] FIGURE 5 illustrates a perspective view of a heater assembly 500 in accordance with various disclosed embodiments. Heater assembly 500 can primarily include a heating element 510 and one or more posts 530. As depicted, posts can be attached to heating element 510 via one or more tabs 516 having an aperture therethrough. Various components of heater assembly 500 that can attach post 530 to heating element 516 are depicted in an expanded view.

[0053] Post 530 can comprise an outer surface that is coated in a protective layer and a conductive body 514. An end of post 530 may be configured for connecting to heating element 510. For instance, a flange portion 564 and an electrical contact portion 562 may be configured to mate with appropriately configured portions of tab 516. Electrical contact 562 can comprise a distal end of a raised portion of post 530. Electrical contact 562 may be exposed or not coated by a protective layer. A first seal gasket 552 may fit around or frame the raised portion having the electrical contact 562. Power gasket 556 may be positioned on the electrical contact 562. The post 530 and gaskets can be positioned in contact with tab 516 as shown by the other posts of FIGURE 5. The second seal member 554 can be disposed onto a top of tab 512 and a threaded member 502 may be inserted through second seal member 554, aperture 512, power gasket 556 and a threaded hole of post 530. In another aspect, a threaded member 506 may be inserted into a bottom threaded hole (not shown) of post 530. In an aspect, contact to an external power supply may be made proximal to threaded member 506, such that the external power supply is sufficiently displaced from the heating element 510.

[0054] While heater assembly 500 is depicted as having six tabs, it is noted that a different number of tabs can be utilized. Likewise, a different number of posts can be utilized. In at least one aspect, a number of electrical connections, tabs and/or posts may be selected based on a desired number of control regions. The control regions can comprise regions that control thermal energy in each region.

[0055] Furthermore, heat path 518 is depicted on top of a heating element 510, however other embodiments may include heat path 518 disposed on a bottom of heating element 510. The heat path 518 can comprise a conductive material. As described herein, conductive materials may include any suitable conductors, such as conductive graphite materials (e.g., pyrolytic graphite), conductive ceramics, conductive metals, and the like. An electrical contact of the heating path 518 may be electrically connected to one or more of a post or heating element 510. Furthermore, while heating path 518 is depicted as a separate component, it is noted that heating path 518 can be etched into or deposited on heating element 510.

[0056] In another aspect, post 530 may include a distal end 570 that is distal from the heating element 510. In an embodiment, the distal end 570 may be protect, removed, or otherwise displaced from the corrosive environment or atmosphere. For instance, the distal end 570 may be protected by a cooling jacket, radiation shield, or the like. It is noted that the distal end 570 may be completely or partially removed from the corrosive environment. For instance, the distal end 570 may be at a location that is in a less corrosive environment than an environment near heating element 510.

[0057] FIGURE 6 is a cross-sectional front view of heating assembly 500. As depicted, post 530 may be coupled to heating element 510 at a connection 600. Turning to FIGURE 7, with reference to FIGURES 5 and 6, illustrated is a cross-sectional view of connection 600 in accordance with various disclosed aspects. Threaded member 502 can secure post 530 to tab 516. In a secured position, first seal gasket 552 is pressed against a portion of tab 516 and flange portion 564 of post 530. Power gasket 556 is pressed between electrical contact 562 and an electrical contact 572 of tab 516. As described herein, electrical contact 562 and electrical contact 572 may comprise not coated or exposed portions of a graphite material. The power gasket 556 may comprise a material that is capable of conducting electricity, such as a flexible graphite material. The power gasket 556, electrical contacts 552 and 562 can be isolated from an external atmosphere 504.

[0058] In at least one embodiment, first seal gasket 552, second seal gasket 554, and power gasket 556 can each comprise a similar or identical material, such as a flexible graphite material. In such an embodiment, if there is a pressure change and/or increase in purge gas flow rate in a hollow internal-post 534, then one or more of the first seal gasket 552 or second seal gasket 554 may be damaged and/or allowing a leak. If one of the seal gaskets is leaking, then it may be likely that the power gasket 556 is corroded and/or being corroded as the gaskets comprise a similar or identical material.

[0059] Referring now to FIGURES 8A, 8B, and 8C, illustrated are heating elements 810, 830, and 850. Each heating element can comprise an aperture for connecting a post as described herein. For instance, heating element 810 can comprise aperture 812, heating element 830 can comprise aperture 832 formed through a tab 836, and heating element 850 can comprise aperture 852.

[0060] In an example, the heating element 810 can comprise a coated base plate heating element and a pattern of grooves or paths 802. The grooves can comprise machined grooves through a graphite layer to expose an underlying boron nitride plate, or the likes. In an example, the grooves 802 can facilitate forming of a continuous strip of conductive material (e.g., pyrolytic graphite, conductive metal, conductive ceramic, etc.) in an electrical series circuit relationship. It is noted that various configurations of paths are possible. Furthermore, various heater assemblies described herein can utilize different numbers of apertures, shapes of heating elements, and the likes. Likewise, grooves 802 may be formed via various methods, such as chemical etching, depositing of materials, or other means.

[0061] What has been described above includes examples of the present specification. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the present specification, but one of ordinary skill in

the art may recognize that many further combinations and permutations of the present specification are possible. Accordingly, the present specification is intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Furthermore, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.

[0062] The foregoing description identifies various, non-limiting embodiments of a thermal management assembly. Modifications may occur to those skilled in the art and to those who may make and use the invention. The disclosed embodiments are merely for illustrative purposes and not intended to limit the scope of the invention or the subject matter set forth in the claims.

CLAIMS

What is claimed is:

1. A thermal management assembly comprising:

a heating element comprising a first electrical contact;

a post operatively attached to the heating element, the post comprising:

a second electrical contact configured to electrically couple with the first electrical contact when the post is operatively attached to the heating element; and

a conductive material operatively providing an electrically conductive path from a power source to the second electrical contact;

a plenum disposed between the heating element and the post when the post is operatively attached to the heating element, and further disposed proximal the first electrical contact and the second electrical contact,

wherein the plenum operatively comprises a purge gas.

2. The thermal management assembly of claim 2, wherein the post further comprises an internal passage in fluid communication with the plenum.

3. The thermal management assembly of claim 1, further comprising a purge gas monitoring component comprising at least one sensor that monitors a parameter of the purge gas.

4. The thermal management assembly of claim 3, wherein the parameter comprises at least one of pressure of the purge gas or a rate of flow additional purge gas supplied to the plenum.

5. The thermal management assembly of claim 3, wherein purge gas monitoring component further comprises at least one interface that initiates an alert in response to determining the parameter meets or exceeds a threshold level.

6. The thermal management assembly of claim 1, further comprising a purge gas supply component in fluid communication with the plenum and operatively supplying purge gas to the plenum.

7. The thermal management assembly claim 1, further comprising at least one gasket operatively positioned between the post and the heating element when the post is operatively attached to the heating element.

8. The thermal management assembly of claim 7, wherein a first gasket of the at least one gasket comprises an electrically conductive material.

9. The thermal management assembly of claim 8, wherein the first gasket is operatively positioned between the first electrical contact and the second electrical contact.

10. The thermal management assembly of claim 8, wherein the first gasket is exposed to the plenum.

11. The thermal management assembly of claim 8, wherein a second gasket of the at least one gasket is operatively positioned between the post and the heating element, wherein an outer perimeter of the second gasket is exposed to an external environment and an inner perimeter of the second gasket is exposed to the plenum.

12. The thermal management assembly of claim 1, wherein the post is removable with respect to the heater.

13. The thermal management assembly of claim 1, wherein the post further comprises a protective layer, and wherein the protective layer generally separates the conductive material from an external environment.

14. The thermal management assembly of claim 1, wherein the post further comprises a distal end that is distal from the heating element, and wherein the distal end is generally removed from an environment proximal the heating element.

15. A thermal management assembly comprising:

a heating element comprising conductive material disposed within a protective material;

one or more posts operatively coupled to the heating element, wherein a post of the one or more posts comprises:

an electrical contact electrically coupled to the conductive material; and

a hollow internal-post comprising a purge gas disposed therein; and

a purge gas monitoring component comprising at least one sensor operatively monitoring at least one property associated with the purge gas.

16. The thermal management assembly of claim 15, wherein the purge gas monitoring component further comprises at least one human interface.

17. The thermal management assembly of claim 16, wherein the human interface comprises at least one of a dial, display screen, light, or speaker.

18. The thermal management assembly of claim 15, wherein the post and the heating element are operatively coupled via at least one of a fastener, clap, threaded member, electrostatic connection, magnetic connection, or a friction-fit connection.

19. The thermal management assembly of claim 15, further comprising another post extending from the heating element coaxial with the post and in a direction generally opposed to the direction of the post.

20. A post operatively coupled to a heating element of a thermal management assembly, the post comprising:

an electrical contact operatively, electrically coupled to a heating element contact;

a conductive material elastically coupled to the contact and operatively coupled to a power source; and

a hollow internal-chamber operatively comprising a purge gas.

21. The post of claim 20, wherein the conductive material comprises a material selected from a group comprising: conductive graphite, conductive metal, or conductive ceramic.

22. The post of claim 20, further comprising a threaded member operatively attaching the post to the heating element.

23. The post of claim 20, wherein a pressure of the purge gas in the hollow internal-chamber is generally greater in value than a pressure of the external environment when the post is in an operative state.

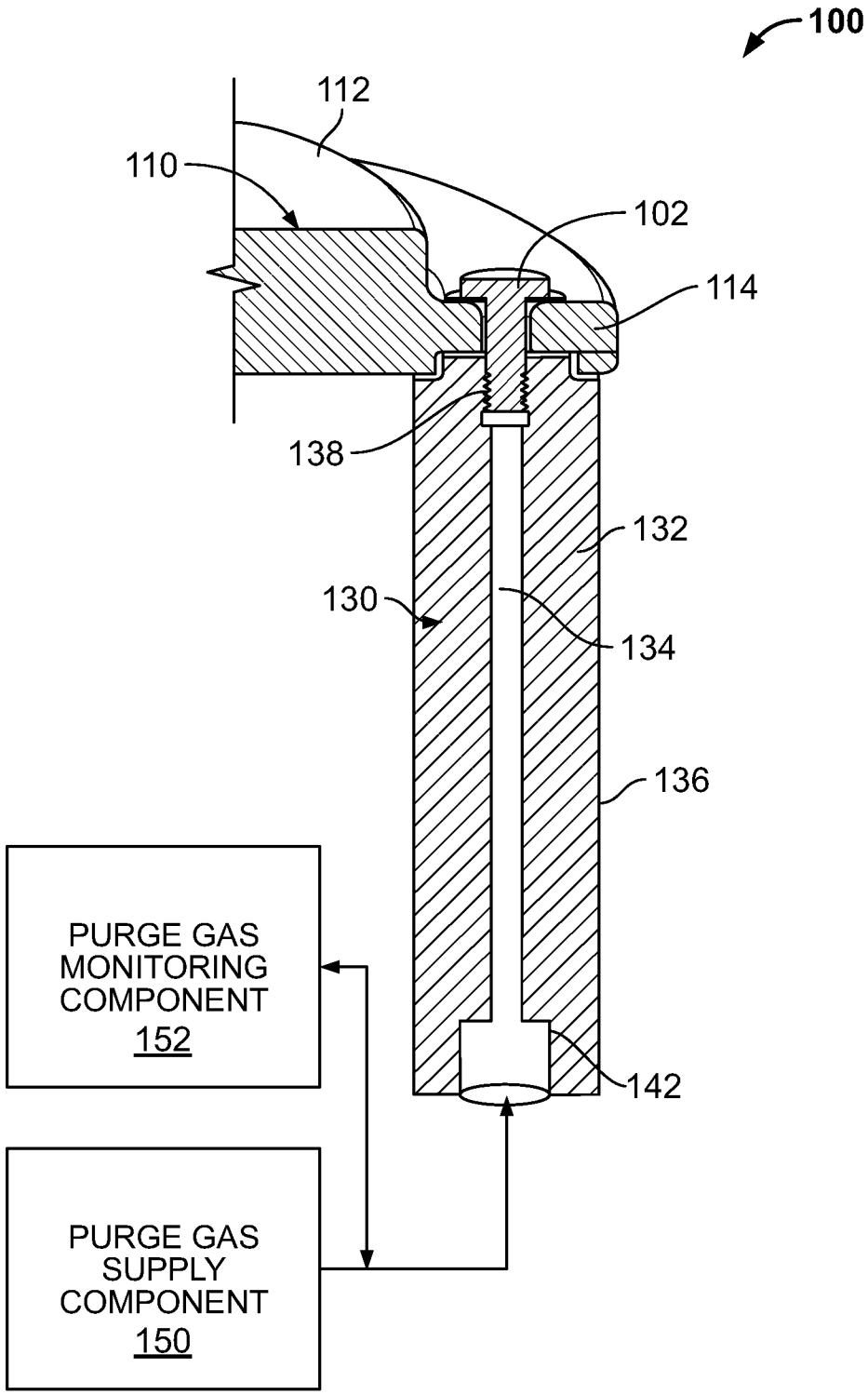

100
112
110
102
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142
PURGE GAS MONITORING COMPONENT 152
PURGE GAS SUPPLY COMPONENT 150

FIG. 1

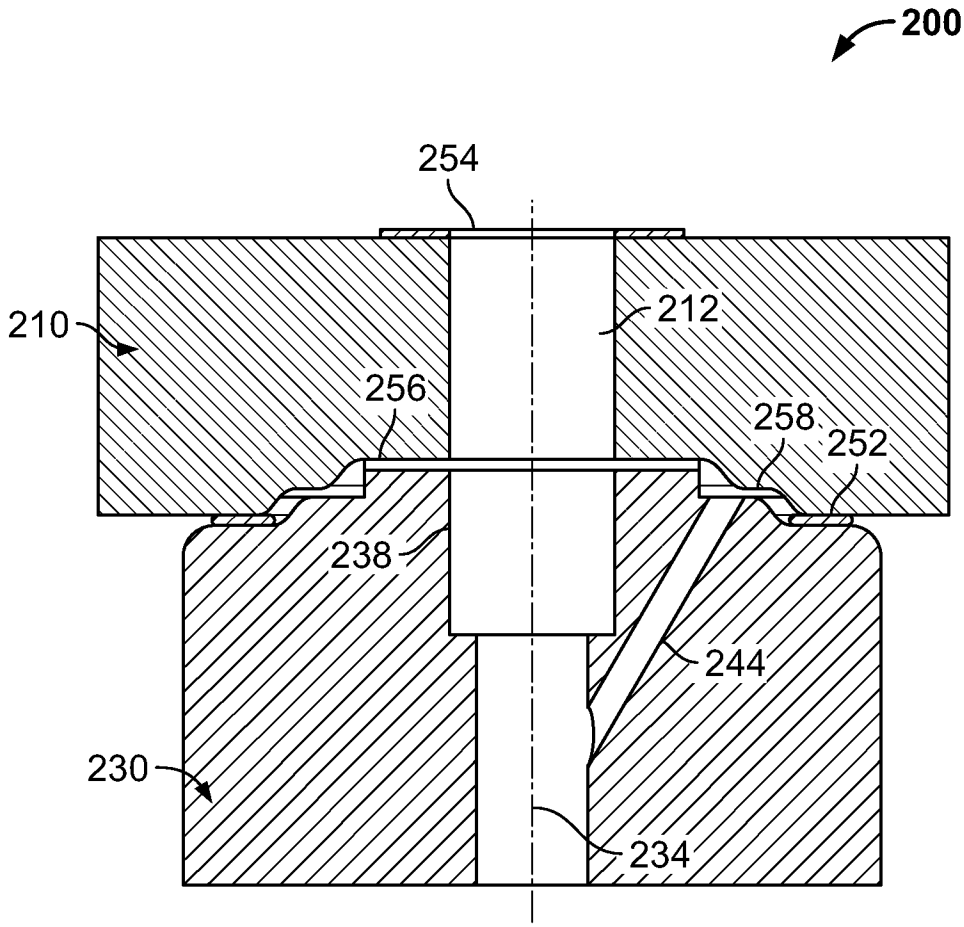


FIG. 2

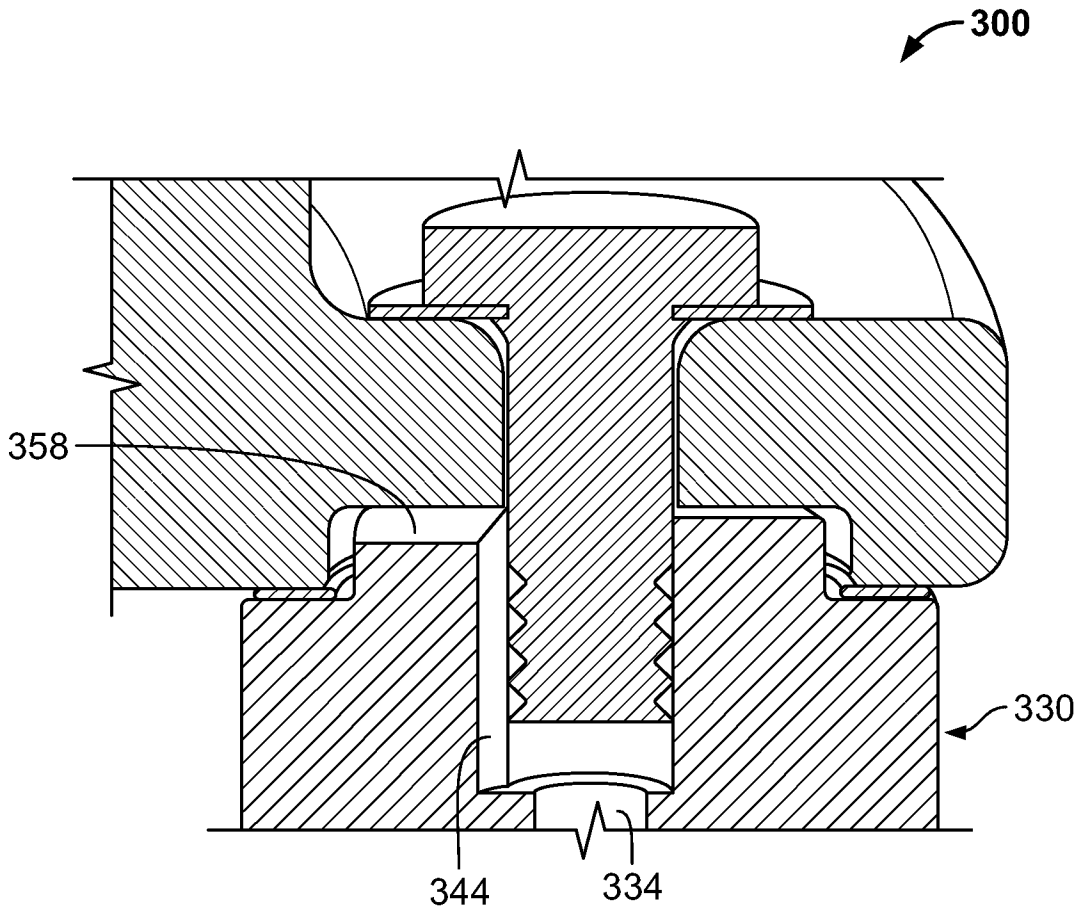


FIG. 3

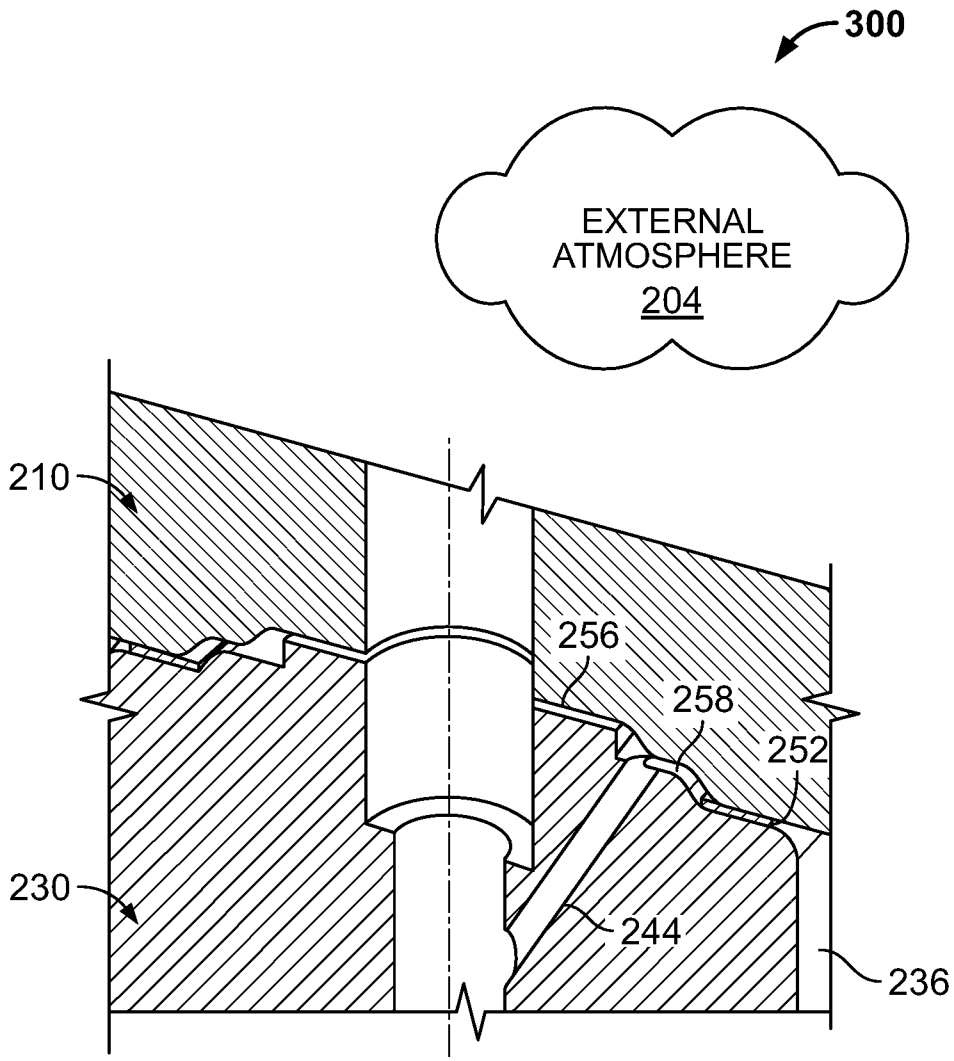


FIG. 4

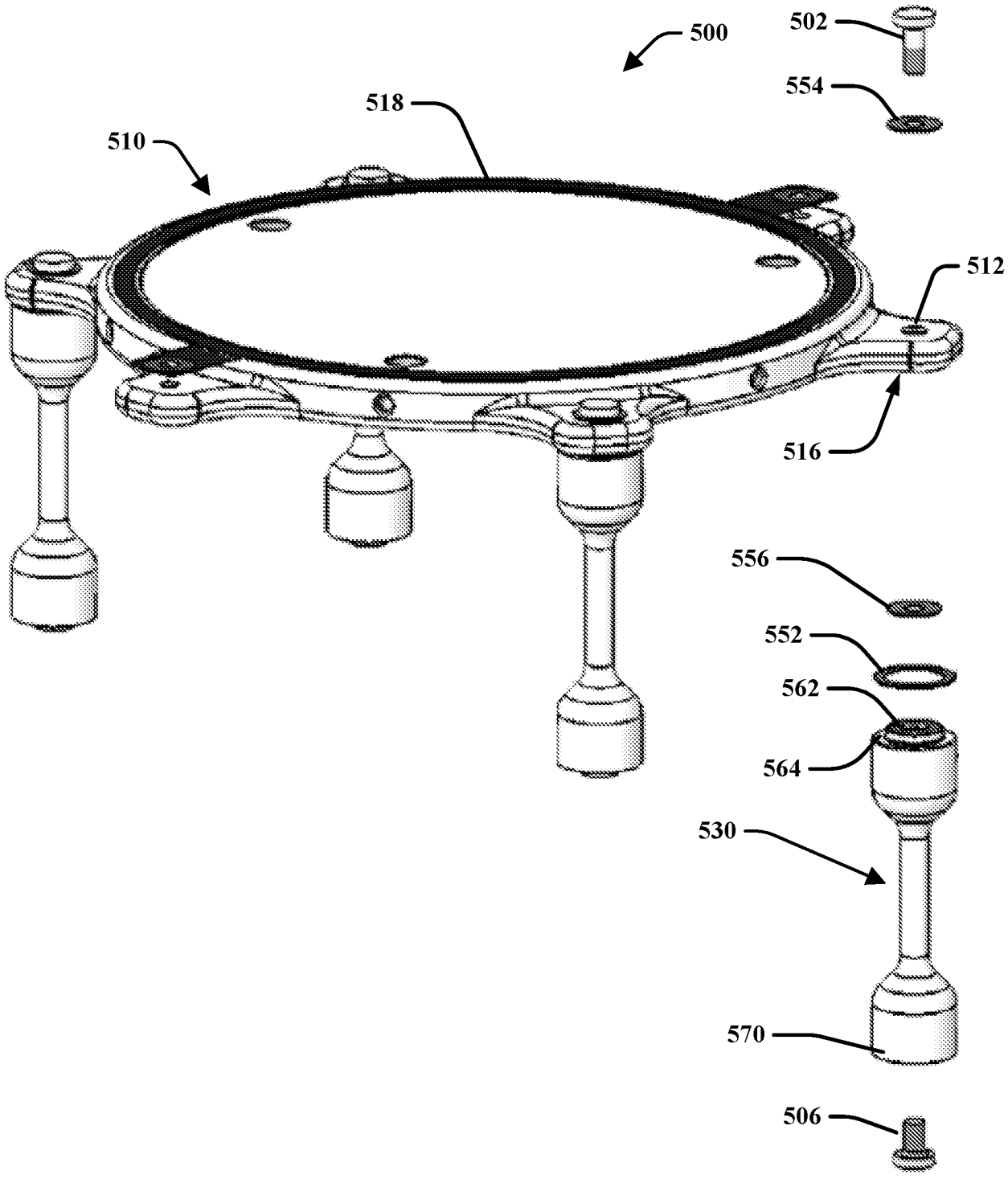


FIG. 5

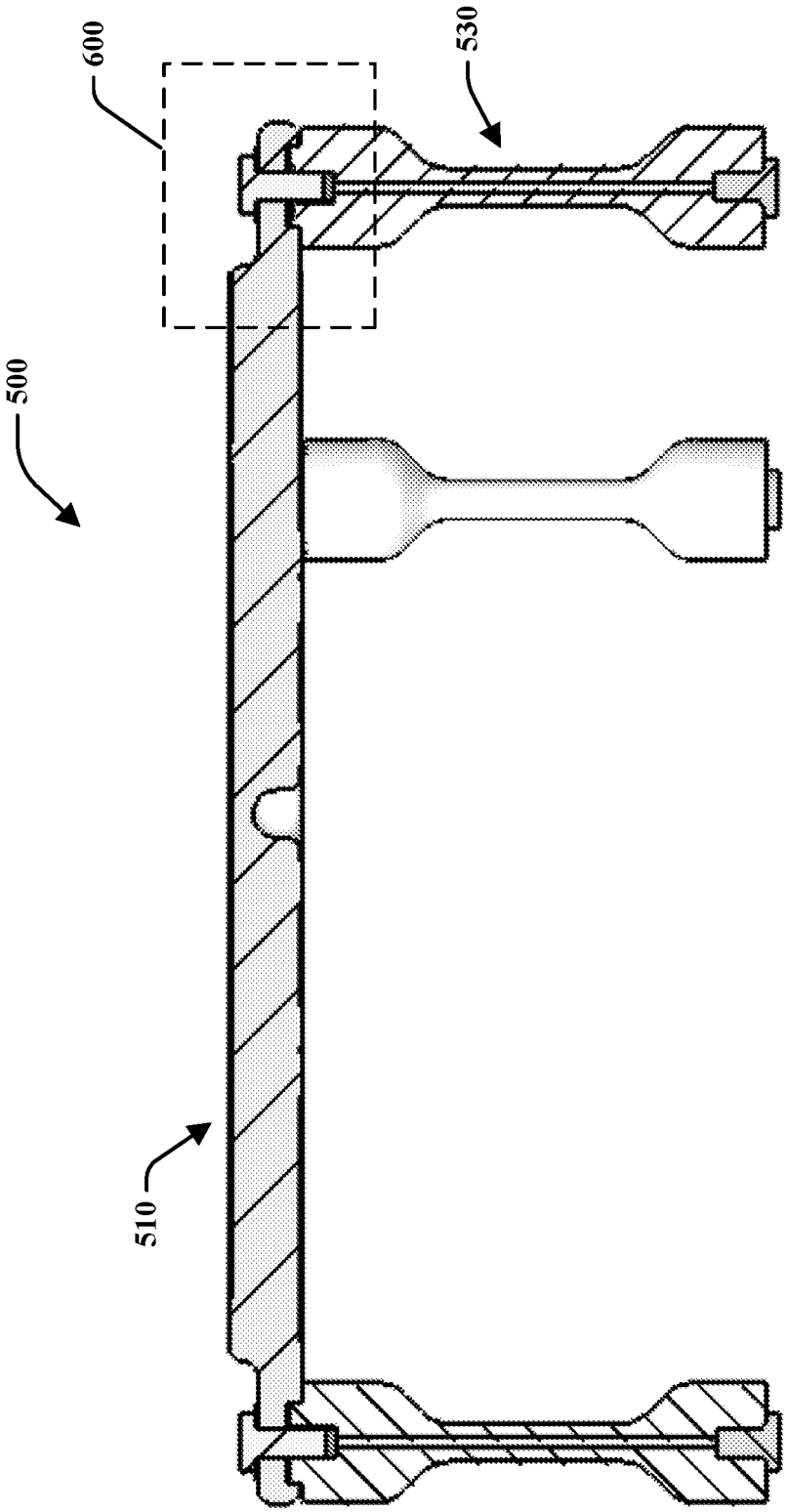


FIG. 6

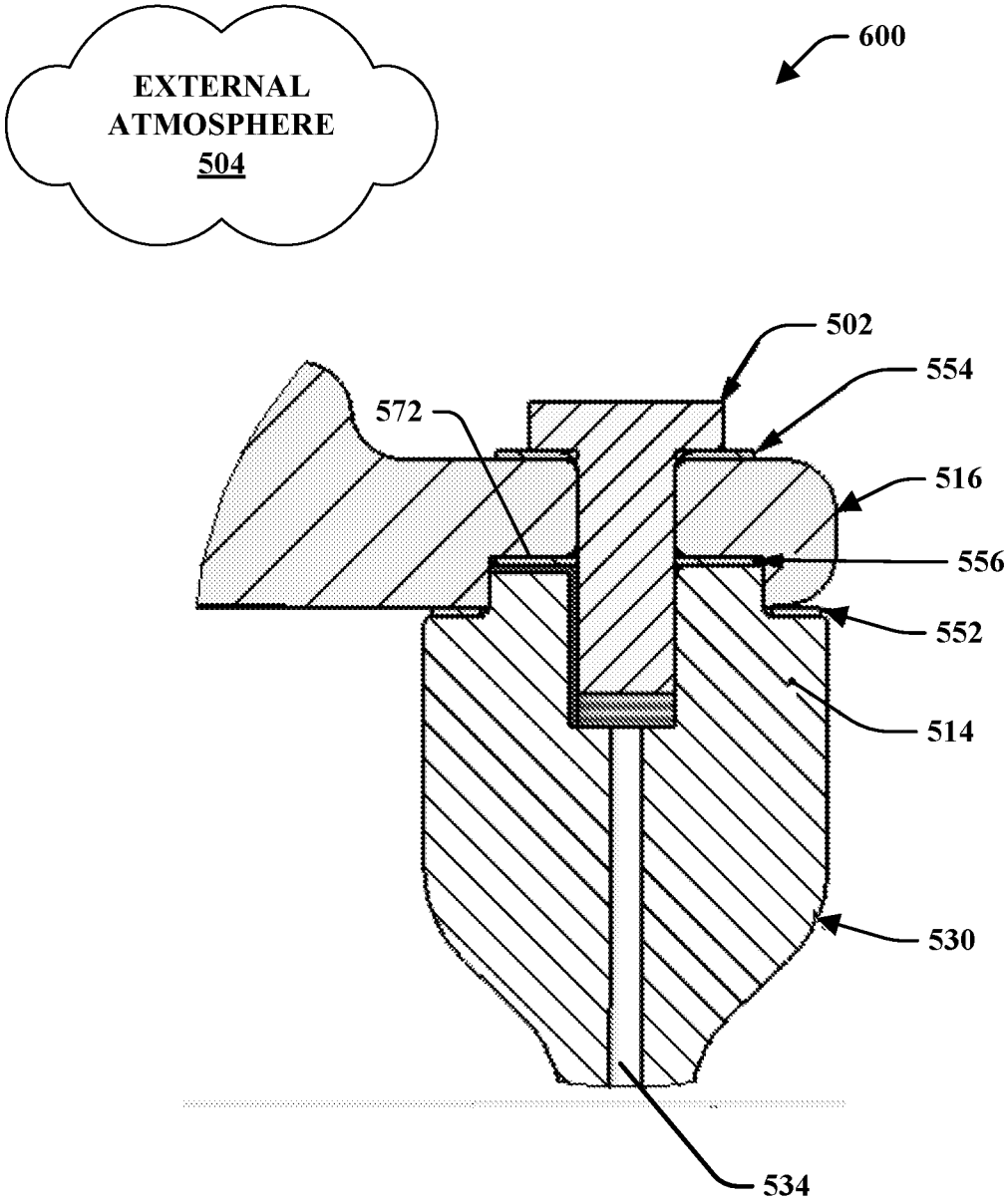

EXTERNAL
ATMOSPHERE
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534

FIG. 7

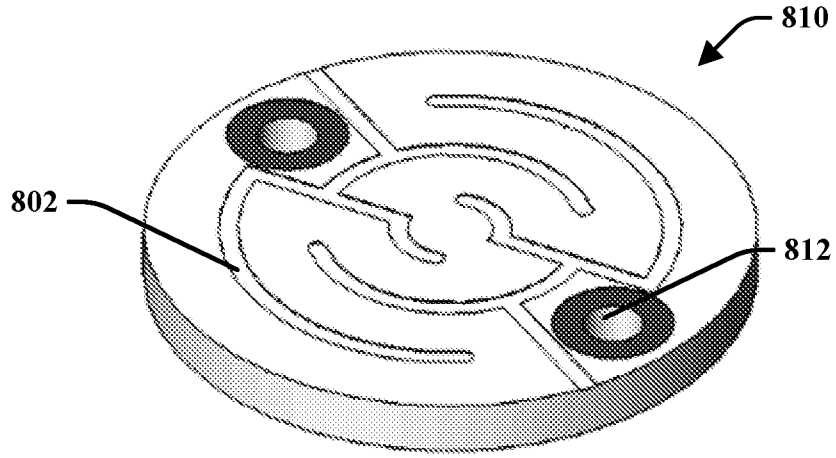


FIG. 8A

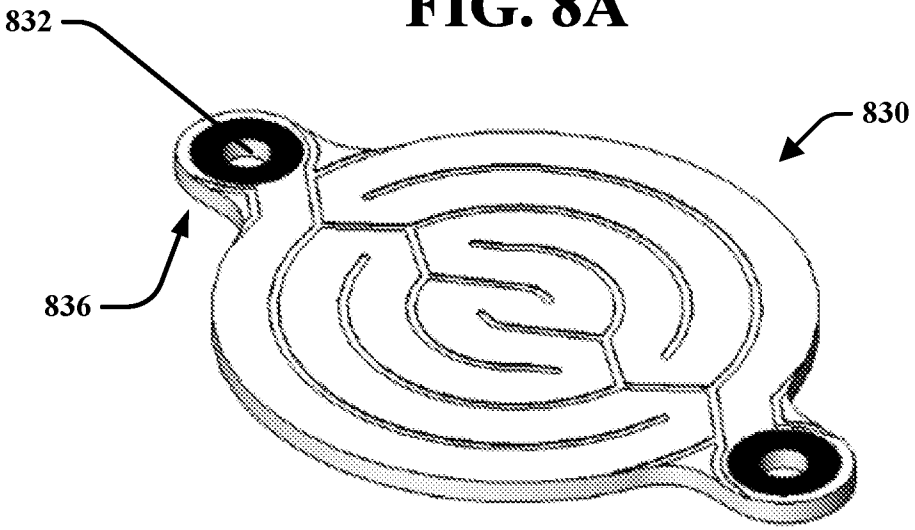


FIG. 8B

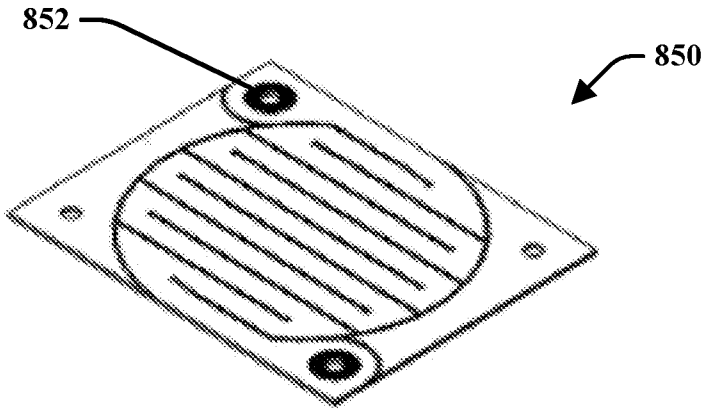


FIG. 8C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US16/19063

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - C23C 16/46, 16/458; H01L 21/687 (2016.01)
CPC - H01L 21/6833, 21/6875; C23C 16/46
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: C23C 16/455, 16/458, 16/46; H01L 21/67, 21/673, 21/687; H05B 3/00, 3/10, 3/16 (2016.01)
CPC: C23C 16/45565, 16/458, 16/46; H01L 21/67005, 21/67103, 21/673, 21/6831, 21/6833, 21/6875, 21/68792; H05B 3/00, 3/143, 3/16

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)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); Google Scholar; EBSCO Discovery Service; IP.com; Keywords: electrostatic*, chuck*, ESC, heat*, electric*, contact*, pressure*, sensor*, purge* gas*, plenum*, chamber*, shower*, flex*, graphite*, wire*

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	WO 2014/134507 A2 (WATLOW ELECTRIC MANUFACTURING COMPANY) September 04, 2014; abstract; figures 1-7; paragraphs [0009, 0022-0026, 0034]	1, 2, 6, 7, 12-14 --- 3-5, 8-11, and 15-23
Y	US 6,119,715 A (RUSSELL, L) September 19, 2000; figure 1; column 4, lines 15-54; column 5, lines 14-16; column 6, lines 3-17	3-5 and 15-19
Y	US 2003/0051665 A1 (ZHAO, J et al.) March 20, 2003; figure 3; paragraphs [0070 and 0078]	8-11 and 22
Y	US 5,343,022 A (GILBERT, M et al.) August 30, 1994; figure 2; column 2, lines 48-68; column 5, lines 1-19	19
Y	CN 201725884 U (XIXIA JINFANGYUAN SEALING MATERIALS CO. LTD) January 26, 2011; See Machine Translation; abstract; figure 1; page 3, paragraph [0006]; page 4, paragraph [0005]	20-23
A	US 2012/0285658 A1 (ROY, S et al.) November 15, 2012; entire document	1-23
A	US 2002/0144657 A1 (CHIANG, T et al.) October 10, 2002; entire document	1-23

☐ 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 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
22 April 2016 (22.04.2016)	05 MAY 2016
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)