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(54) **Title**: MECHANICAL CLAMPING ASSEMBLY FOR A RING-SHAPED COMPONENT WITHIN A VACUUM CHAMBER FOR SUBSTRATE PROCESSING

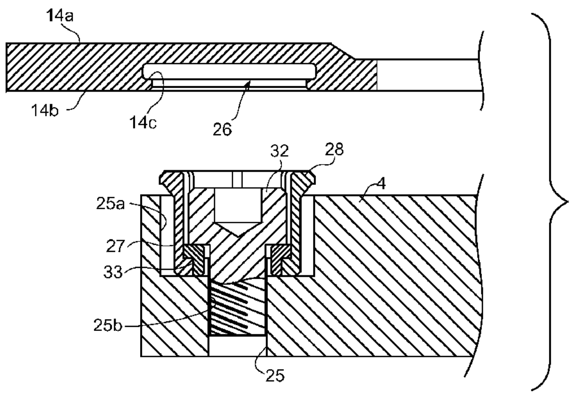

FIG. 4A

(57) **Abstract**: A mechanical clamping apparatus installed on a rear surface of a ring-shaped component that surrounds an outer periphery of a substrate on which a process is performed, the mechanical clamping apparatus for removably and self-alignment mounting the ring-shaped component to a mounting table containing a cooling mechanism for mounting thereon the substrate to be processed, wherein the mounting table is further installed within a vacuum or depressurized chamber for accommodating the processing of the substrate, comprising a plurality of apertures at the rear surface of the ring-shaped component; and a means for removably aligning and securing, using the apertures, the rear surface of the ring-shaped component to the mounting table at a specified load.

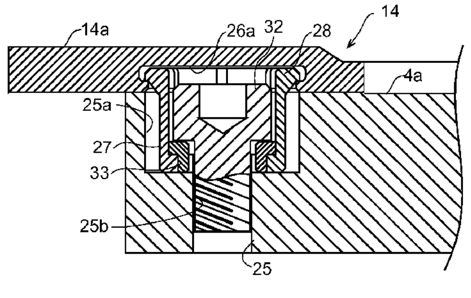

FIG. 4B

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MECHANICAL CLAMPING ASSEMBLY FOR A RING-SHAPED COMPONENT WITHIN A VACUUM CHAMBER FOR SUBSTRATE PROCESSING

FIELD OF THE INVENTION

The present invention relates to a mechanical means for fastening together, while maintaining optimal thermal conductivity for cooling purposes, a ring-shaped component such as a substrate ring, to a mounting apparatus arranged within a vacuum or depressurized chamber, such as a chamber used in semiconductor wafer processing.

BACKGROUND OF THE INVENTION

In a plasma processing apparatus used for semiconductor manufacturing processes, there is a processing chamber where a substrate mounting apparatus is provided, on which a substrate such as a wafer is mounted. A high-frequency voltage is then applied under vacuum to the processing chamber to produce a plasma that is used for an etching process performed on the substrate. In this type of plasma processing apparatus, the use of a substrate ring over the mounting table to hold an outer periphery of the substrate on which the process is performed is known to enhance the uniformity of the plasma that is applied on a plane of said substrate.

A substrate ring used for a plasma processing apparatus is exposed to plasmas so that the substrate ring itself can be etched then eroded. As the erosion of a substrate ring deteriorates the uniformity of the plasmas used in the process over the semiconductor wafer plane, an eroded substrate ring must be replaced with a new one when the erosion of the ring has proceeded to a certain degree.

A potential problem is that the wafer chuck and the component such as the substrate ring, etc.may not be consistently aligned to each other after each installation during a preventative maintenance (PM) cycle. Since the replaceable component is manually installed (based on manual, visually best-fit installations), it is also more difficult to install and align the component properly onto the wafer chuck. Such misalignment will create an inconsistent clearance gap between the chuck and the replaceable component, which may result in arcing and damage to the wafer chuck by the processing plasma. In severe cases, such damage may create particles on the wafer and the need for a costly replacement of a new wafer chuck.

Most semiconductor wafer processing chambers require high radio frequency (RF) power, resulting in high temperatures on the wafer and the surrounding components. Thus, the wafer is typically supported by a wafer chuck which is designed with a delicate cooling system that enables heat transfer from the hot wafer to a cold chuck via a helium backside during processing. Supporting the wafer chuck, there is the above-mentioned ring-shaped component such as a substrate ring (for example, a focus ring, edge ring, shadow ring or deposition ring), which precisely fits onto the wafer chuck but with clearance allowing its easy removability and replacement during preventative maintenance (PM) cycles.

However, a problem with the above-mentioned helium backside method is that potentially, the wafer chuck is still unable to support cooling via the helium backside on the component surrounding the wafer, such as the substrate ring, etc. As the result, the component temperature may be always hotter than the wafer. The mismatch temperature between the wafer and the surrounding component results in poor wafer yield.

Furthermore, in the plasma processing apparatus with such a configuration as described above, a vacuum insulation layer can be formed between the mounting table and the substrate ring inside a depressurized chamber, which causes poor heat transfer between the mounting table and the substrate ring. If said vacuum insulation layer is formed, it is possible that the substrate ring will not be cooled down. The rise of the temperature of the substrate ring can result in the deterioration of characteristics of etching performed on the outer periphery of the wafer, for example, deterioration of an etching rate, a hole through property (a property allowing by etching to reliably dig up to a predetermined depth), and the aspect ratio of etching.

If the plasma process is continued under these circumstances, heat accumulates on the substrate ring, resulting in the unstable temperature of the substrate ring that hinders a uniform etching process that could have been performed on a plurality of wafers in the same lot. Therefore, the balance temperatures between wafer and surrounding component become very critical.

To solve such problems, a method of actively controlling the temperature of a substrate ring has been developed by improving an efficiency of heat transfer between a substrate ring and a mounting table. According to such prior art, the heat transfer efficiency is improved by interposing a heat transfer sheet in the form of a gel between a substrate ring and a mounting table, and also by mechanically pressing the substrate ring against the mounting table.

A heat transfer sheet of this sort is very effective in improving heat transfer between a substrate ring and a mounting table. However, this heat transfer sheet is made of gel polymer, which poses a problem. The gel polymer is likely to adhere to metal or a ceramic surface coming into contact therewith. Particularly, when the substrate ring and the mounting table are mechanically pressed against one another to increase the rate of heat transfer in between, the gel polymer of the heat transfer sheet frequently adheres to the surface of the mounting table tenaciously. Such a heat transfer sheet adhered tenaciously cannot be easily removed without utilizing a dedicated stripping jig. This causes work efficiency in replacing the substrate ring or the mounting table to decrease greatly.

Moreover, some components of the heat transfer sheet often remain on the surface of the substrate ring or the mounting table as grime or debris, or adhesive substances. After the tenaciously adhered heat transfer sheet is stripped away, the surface needs to stay clean for subsequent processes.

In contrast, another prior art method discloses an invention directed to a substrate ring that is easily removable from a mounting apparatus, although the substrate ring is mechanically pressed, by performing a process to make at least one side of the heat transfer sheet non-adhesive.

In each of the above prior art methods, an attempt is made to obtain heat transfer between a substrate ring and a mounting apparatus via a mechanical pressing unit. However, such a mechanical unit makes the configuration of the apparatus more complex. Thus, a substrate ring and a plasma processing apparatus having optimal heat transfer capacity, reliable and accurate alignment, and removability without requiring complex mechanical assemblies are desired.

SUMMARY OF THE INVENTION

A mechanical clamping apparatus installed on a rear surface of a ring-shaped component that surrounds an outer periphery of a substrate on which a process is performed, the mechanical clamping apparatus for removably and self-aligningly mounting the ring-shaped component to a mounting table containing a cooling mechanism for mounting thereon the substrate to be processed, wherein the mounting table is further installed within a vacuum or depressurized chamber for accommodating the processing of the substrate has a plurality of apertures at the rear surface of the ring-shaped component; and a means for removably aligning and securing, using the apertures, the rear surface of the ring-shaped component to the mounting table at a specified load.

In a first aspect of the invention, the means has a clamping ring having a cylindrical shape, with an outwardly extending lip at one circular end, for repeatedly snapping into and out of a respective aperture at the rear surface.

In another aspect of the invention, the mechanical clamping apparatus has a plurality of slitted areas running from the circular end down a side of the clamping ring, for snapping into and out of one of the apertures at the rear surface.

Other features and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Below, the invention is explained in detail with reference to exemplary drawings, as follows:

FIG. 1 is a sectional schematic diagram showing an example of a plasma processing apparatus relating to an embodiment of the present invention;

FIG. 2 is a side/top perspective view showing a substrate ring and a corresponding cylindrical electrostatic chuck of a mounting table of the present invention;

FIGS. 3A-C are side, top, bottom, and detailed sectional (of area 3C of FIG. 3A, along line 3A-3A of FIG. 3B) views, respectively, showing the substrate ring of the present invention;

FIGS. 4A-B are side sectional views showing a structure of a mechanical clamping assembly according to the present invention, with the substrate ring in the installed and uninstalled positions, respectively;

FIGS. 5A-C are top, side, and sectional (along line 5C-5C of FIG. 5A) views, respectively, showing a clamping ring of the present invention;

FIGS. 6A-C are top, side and a sectional (along line 6C-6C of FIG. 6A) views, respectively, showing a bushing ring of the present invention; and

FIGS. 7 is a detailed sectional view of another structure of the apertures at a bottom side of the substrate ring of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to mechanical clamping assembly for a substrate ring or other similar component relating to a mounting apparatus of a substrate to be processed. Thus, first, the mounting apparatus of a substrate to be processed used to carry out the present invention will be described.

FIG. 1 is a sectional schematic diagram showing an example of a plasma processing apparatus 1 used in an embodiment of the present invention. The apparatus 1 includes a chamber 3 to accommodate a semiconductor wafer 2 and an electrostatic chuck 4 and a cylindrical susceptor 5 are arranged inside the chamber 3 as part of a mounting table to mount the wafer 2 thereon. A side exhaust passageway 6 to exhaust gases are formed between an inner wall surface of the chamber 3 and a side surface of the susceptor 5 and an exhaust plate 7 composed of a perforated plate is arranged halfway through the side exhaust passageway 6. The exhaust plate 7 has a function as a partition plate that partitions the chamber 1 into upper and lower parts, creating the upper part as a reaction chamber 8 and the lower part as an exhaust chamber 9. The exhaust chamber 9 has an exhaust pipe 10 opened therein and the chamber 3 is evacuated by a vacuum pump (not shown).

The electrostatic chuck 4 containing an electrostatic electrode plate 11 is arranged above the susceptor 5. The electrostatic chuck 4 has a shape in which an upper disc-like member with a smaller diameter is put on top of a lower disc-like member. A layer of dielectrics (such as ceramic) is formed on the upper surface of the upper disc-like member, a dielectric potential is generated on the surface of the upper disc-like member by a high DC voltage being applied to the electrostatic electrode plate 11 connected to a DC power supply 12, and the wafer 2 mounted thereon is adsorbed and supported by a Coulomb force or Johnson-Rahbek force.

The electrostatic chuck 4 is fixed to the susceptor 5 by being screwed and a substrate ring 14 is mounted between an insulating member 13 and the wafer 2. The insulating member 13 acts to prevent plasma from spreading too much toward an outer periphery direction and controls an electric field to prevent plasma from leaking from the exhaust plate 7 to an exhaust side after spreading too much. The surface of the substrate ring 14 is made of a conductive material such as silicon and silicon carbide. The substrate ring 14 covers an outer periphery of the wafer 2, the surface thereof is exposed to the space of the reaction chamber 8, and has a function to cause plasma in the reaction chamber to converge on the wafer.

Plasma is generated inside the reaction chamber by action of high frequency power applied to high frequency power supply 16 and high frequency power applied to the susceptor 5 from the lower high frequency power supply 17. A reaction gas is supplied to the gas introduction shower head 15 from a gas introduction pipe 18 and further supplied to the reaction chamber 8 after being converted into plasma by passing through many gas holes 21 provided in a upper electrode plate 20 via a buffer chamber 19.

The wafer 2 after being exposed to plasma rises in temperature and so is cooled by heat transfer to the susceptor 5. Thus, the susceptor 5 is formed of a metallic material having good heat conductivity and a coolant passageway 22 is provided therein to circulate a coolant such as water and ethylene glycol from a coolant supply pipe 23 for cooling.

Many heat transfer gas supply holes 24 are provided on the surface that adsorbs the wafer 2 and the rear surface of the wafer 2 is cooled by causing helium to flow out of these holes.

Thus, the wafer 2 is adsorbed and supported on the electrostatic chuck 4. The electrostatic chuck 4 is fixed to the susceptor 5 by being screwed and the coolant passageway 22 is provided inside the electrostatic chuck 4.

The substrate ring 14 is a ring-shaped component having a ring-shaped body made of a dielectric material or a conductive material. It should be noted that the ring-shaped component of the present invention is not limited to substrate rings and may include other components, such as focus edge rings, shadow rings or deposition rings. Additionally, it should be understood that such components may have shapes other than a ring-type, as may be commonly known in the art, such as a square-type, rectangular-type, etc. Typically, such components may be made of silicon, quartz, aluminum oxide, or other suitable materials as known in the art.

FIG. 2 shows a side/top perspective view of the substrate ring 14 and the round electrostatic chuck 4 of the mounting table of the present invention. As illustrated in FIG. 2, the top surface 14a of the substrate ring 14 is essentially flat and shows no openings. As shown in the drawing, the top surface of the electrostatic chuck 4 has a plurality of evenly-spaced holes 25. These holes may have any of a variety of ring-shaped (or other-shaped) layouts, and they may even make use of holes already pre-existing on a standard electrostatic chuck 4 or mounting table.

FIGS. 3A-D show side, top, bottom, and detailed sectional (of area 3C of FIG. 3A, along line 3A-3A of FIG. 3B) views, respectively of the substrate ring 14. The bottom or rear surface of the substrate ring 14 has a plurality of evenly spaced, round openings or apertures 26 made therein. Again, as shown in FIG. 3D (and in FIGS. 4A-B as described below), these apertures 26 extend only partly through the thickness of the substrate ring 14, such that the apertures 26 are hidden and not visible at all from the top of the ring. Thus, the present invention requires no alterations at all to the top surface of the substrate ring 14. Indeed, if using pre-existing holes 25 on the electrostatic chuck 4, the present invention may require minimal machining or alterations to an existing mounting apparatus.

FIGS. 4A-B illustrate side sectional views of an embodiment of the mechanical clamping assembly 27 of the present invention, with the substrate ring 14 in just prior to installation position (or snapped off position) and also in the installed (snapped on) position . As clear from those views, the substrate ring 14 may typically have a larger overall diameter than the electrostatic chuck 4 of the mounting table.

The sectional view also illustrates an example of a cutout design for the apertures 26 at the rear surface of the ring 14. As shown in detail in these figures (and in FIGS. 3D and 7), the apertures 26 include an upper portion 26a closer to the top surface 14a having a larger diameter, and a lower portion 26b opening out toward the bottom surface 14b of the substrate ring 14. Essentially, this configuration forms a circular ridge 14c within the wall of the aperture 26, which surface extends inwardly and then slopes outwardly toward the ring's bottom surface 14b. Essentially, these apertures 26 form a "female" portion for the snap-fit mechanism of the present invention.

The mechanical clamping assembly 27 of the present invention includes a cylindrically-shaped clamping ring 28 for insertion into and positioning within a respective hole 25a on the electrostatic chuck 4. Regarding the holes 25, as shown in FIGS. 4A-B, each of the holes 25 in the electrostatic chuck 4 has a larger-diameter section 25a opening onto the top surface 4a of the chuck 4, and a smaller-diameter section 25b at a center of section 25a, extending deeper into the chuck 4.

The clamping ring 28 of the present invention may be made of elastically deformable materials such as metals, plastics (such as PAI or PEEK), rubbers or other suitable materials as known in the art.

As further illustrated in FIGS. 5A-C, the clamping ring 28 has an outwardly extending lip 29 at one circular shaped end 30. This lip 29 has an inwardly sloped portion 29a toward the top and a recessed, inwardly inclining portion 29b toward the bottom. Thus, this circular shaped end 30 with the lip 29 essentially forms a “male” portion for the snap-fit mechanism of the present invention.

As shown in the snapped off and snapped on views of FIGS. 4A and 4B, in operation the clamping ring 28 is first pressed into the apertures of the substrate ring 14, such that the circular end 30 slightly compresses inwardly and the respective sloped parts allow the end 30 to slide into, and be received within, the wider portion 26a of the aperture 26. That is, the circular ridge 14c within the aperture 26 on the substrate ring 14 forms a removable interference fit with the clamping ring 28. The arrangement of the ridge 14c within the respective aperture 26 forms a “bottle neck”, through which the clamping ring 28 in the end 30 area must compress inwardly, in order to pass through. After going through the interference (bottle neck), the end 30 expands or releases back to its natural state. Thus, the ridge 14c temporarily prevents the exit of the lip 29 from the aperture 26, resulting in the “snapping on” and secure installation of the clamping ring 28 into the respective aperture 26 of the substrate ring 14, until the clamping ring 28 may be compressed again to pass the end 30 through the bottle neck, for its “snapping off” and removal from the substrate ring 14. By appropriately designing the dimensions (tolerances) of the aperture 26 and of the lip 29 area, the timing, forces and other factors for the snapping on/off operations can be varied and controlled.

To further aid in the compression and release of the circular end 30 area of the clamping ring 28 relating to the above-described snapping in/out operations, a plurality of slits 31 may extend partly and longitudinally from the edge and down the side of the clamping ring 28. Thus, the above-described arrangement permits the easy self-alignment and secure attachment/detachment of the clamping ring 28 with respect to rear surface of the substrate ring 14.

The mechanical clamping assembly 27 may further include a bushing ring 33 (as shown in greater detail in the top, side and sectional views of FIGS. 6A-C), which may be interposed between the clamping ring 28 and the clamping bolt 32, as a further protection and lining therein. The bushing ring 33 may be made of similar materials as described above for the clamping ring 28.

Returning to FIGS. 4A-B, the present invention may also include a clamping bolt 32 for extending through a central opening at an other end of the clamping ring 28 and of the bushing ring 33 and engaging with and removably securing to a section 25b of a respective hole 25 in the electrostatic chuck 4. The clamping bolt 32 may be M5 or any standard or suitable size, may be made of metal or plastic or other appropriate material, and may be threaded or have any other engagement means as known in the art.

The tightening of the clamping bolt 32 to section 25b of the hole 25 applies a pressure on both the elastically deformable bushing ring 33 and on the clamping ring 28, and provides a torque load on the hole 25 of the electrostatic chuck 4 to which the bolt becomes secured. Then, the bushing ring 33 assists in distributing and absorbing the applied pressures to protect the clamping ring 28 and the bolt 32, and to restrain the bolt 32 from becoming untightened. The bushing ring 33 also protects against the wear of the opposing surfaces of the bolt 32 and the clamping ring 28. However, while under such loads, the bushing ring 33 may also permit some degree of self-movement (leeway) of the clamping ring 28. By designing the dimensions (tolerances) of clamping assembly parts such as the bushing 33 appropriately, one can vary and control the amount of such self-movements, to optimize the proper and quick alignment of the clamping ring 28 with the aperture 26 at the rear surface of the substrate ring 14 during the above-described snapping in/out operations.

In one embodiment, when tightened, the bolt may experience a load of approximately 60 lbs and may be stressed to about ¼ ultimate tensile strength (12,000 psi). At such a load and positioning, the clamping ring 28 of the mechanical clamping assembly 27 enables a precise, simple and suitable aligning of the corresponding substrate ring 14 and wafer 2 with the electrostatic chuck 4 and mounting table. Furthermore, the clamping bolt 32 is selected an/or designed to provide such a specified load that a heat transfer contact area between the rear surface of the substrate ring 14 and the surface of the electrostatic chuck 4 of the mounting table is maximized or optimized. Such optimization is particularly valuable in a vacuum chamber, to prevent the formation of a gap and the above-mentioned vacuum insulation layer, between the two surfaces.

FIG. 7 shows a further example of the apertures 26 designed into at the rear surface of the substrate ring 14. In the arrangement shown in FIG. 7, additional ribs 34 protruding from the rear surface can further guide in the easy and precise self-alignment and positioning of the circular end 30 of the clamping ring 28 at the respective aperture 26. That is, either a manual or mechanical means can move the circular edge 30 of the clamping 28 about the rear surface 14b until it engages with and is guided by the rib 34 into proper positioning, in order to accomplish the “snap-fit” securing as described above.

It should be understood that the substrate ring 14 or other similar ring-shaped component of the present invention may be a single ring-shaped body, or it may also comprise an assembly of more than one ring-shaped body that can fit together to form an integrated part. As an example, the substrate ring 14 could include two ring-shaped parts of different diameters that can fit together to form a single ring-shaped body. Many similar combinations of a plurality of assembled rings may be envisioned, as could be practiced in the art. Also, as stated above, it should be clearly understood that the component is also not limited to just rings in shape and may have other shapes such as squares, rectangles, other polygons, etc.

In operation, the mechanical clamping assembly 27 of the present invention provides a highly simple assembly for enabling the quick and stable positioning of components within the vacuum chamber. Additionally, unlike other, more complex assemblies, the present arrangement has the advantage of being non-visible (hidden from view) upon installation.

By merely having the clamping ring 28 inserted into the upper section 25a of a hole 25 of the electrostatic chuck 4, with the clamping bolt 32 tightened therein and secured to a respective section 25b of the hole, the substrate ring 14 can be snapped off from the lip 29 of the clamping ring 28 (as shown in FIG. 4A) by manually or mechanically, slightly compressing the clamping ring 28 as made easier 31 by the above-described slits. Then, a replacement can be snapped onto the clamping ring 28 (as shown in FIG. 4B) via a similar compression operation, for a quick, simple, and stably positioned replacement during a PM cycle.

Furthermore, the elastic deformability of the clamping ring 28 (and the optional bushing ring 33) allows the assembly to maintain a sufficient clamping force under thermal expansions and contractions of the system. Since the assembly remains within a linear elastic range throughout such thermal expansions/contractions, its design allows the maintaining of a sufficient clamping force/load, in order to provide stable, accurate positioning of the removable components. The storage of elastic energy in the clamping ring 28 and bushing ring 33 also prevents damage to the other components due to the thermal effects.

In another embodiment of the present invention, plural strips of a flat, heat transfer sheet (now shown) may be sandwiched between the substrate ring 14 and the electrostatic chuck 4, and between the mechanical clamping assemblies 27, for further improving the heat transfer between the substrate ring 14 and the mounting table. The heat transfer sheet may be integrated beforehand with the substrate ring 14. The heat transfer sheet is used to promote heat transfer by being sandwiched between the two contacting surfaces of the substrate ring 14 and the electrostatic chuck 4 and may be made of a polymeric material (suitably gel polymer) rich in flexibility and heat conductivity. It the present invention, it may even be beneficial to adhere one surface of the heat transfer sheet to the substrate ring 14 beforehand so that heat transfer between the heat transfer sheet and the substrate ring 14 is not lost.

The formed thickness of such a sheet may preferably be 0.1 to 1.0 mm and a sheet formed in a thickness of0.2 to 0.5 mm is particularly preferable. A sheet whose formed thickness is less than 0.1 mm has a low hardness and may have poor handling properties and low adhesiveness. On the other hand, if the thickness exceeds 1 mm, thermal resistance increases so that desired heat conductivity may not be obtained.

It is to be understood that the above-described embodiment is illustrative of only one of the many possible specific embodiments which can represent applications of the principles of the invention. For example, one can envision the use of the mechanical clamping assembly of the present invention in various types of wafer fabrication processes (such as etching, chemical vapour deposition (CVD) or physical vapour deposition (PVD)). Numerous and varied other arrangements can be readily devised by those skilled in the art without departing from the spirit and scope of the invention.

CLAIMS

What is claimed is:

1. A mechanical clamping apparatus installed on a rear surface of a ring-shaped component that surrounds an outer periphery of a substrate on which a process is performed, said mechanical clamping apparatus for removably and self-aligningly mounting said ring-shaped component to a mounting table containing a cooling mechanism for mounting thereon the substrate to be processed, wherein said mounting table is further installed within a vacuum or depressurized chamber for accommodating said processing of said substrate, comprising:

a plurality of apertures at the rear surface of the ring-shaped component; and

a means for removably aligning and securing, using said apertures, said rear surface of the ring-shaped component to said mounting table at a specified load.

2. The mechanical clamping apparatus of claim 1, wherein said means comprises a clamping ring having a cylindrical shape, with an outwardly extending lip at one circular end, for snapping into and out of one of said apertures at said rear surface.

3. The mechanical clamping apparatus of claim 2, wherein a ridge extending within said aperture removably secures said outwardly extending lip on said clamping ring within said aperture, for securing said rear surface to said mounting table.

4. The mechanical clamping apparatus of claim 2, further comprising a plurality of slitted areas running from the circular end down a side of said clamping ring, for snapping into and out of one of said apertures at said rear surface.

5. The mechanical clamping apparatus of claim 2, wherein said clamping ring is made of an elastically deformable material.

6. The mechanical clamping apparatus of claim 3, wherein said means further comprises a clamping bolt for removably and load-bearingly fastening said clamping ring to a hole in said mounting table.

7. The mechanical clamping apparatus of claim 5, further comprising a bushing ring interposed between said clamping ring and said clamping bolt.

8. The mechanical clamping apparatus of claim 1, wherein said ring-shaped component is a substrate ring.

9. The mechanical clamping apparatus of claim 1, wherein said specified load maximizes a heat transfer contact area between said rear surface of the ring-shaped component and the mounting table.

10. The mechanical clamping apparatus of claim 1, further comprising a heat transfer sheet interposed between said rear surface and the mounting table, for optimizing a heat conductivity between the rear surface and the mounting table.

11. The mechanical clamping apparatus of claim 9, wherein said heat transfer sheet is removably attached to said rear surface of the ring-shaped component.

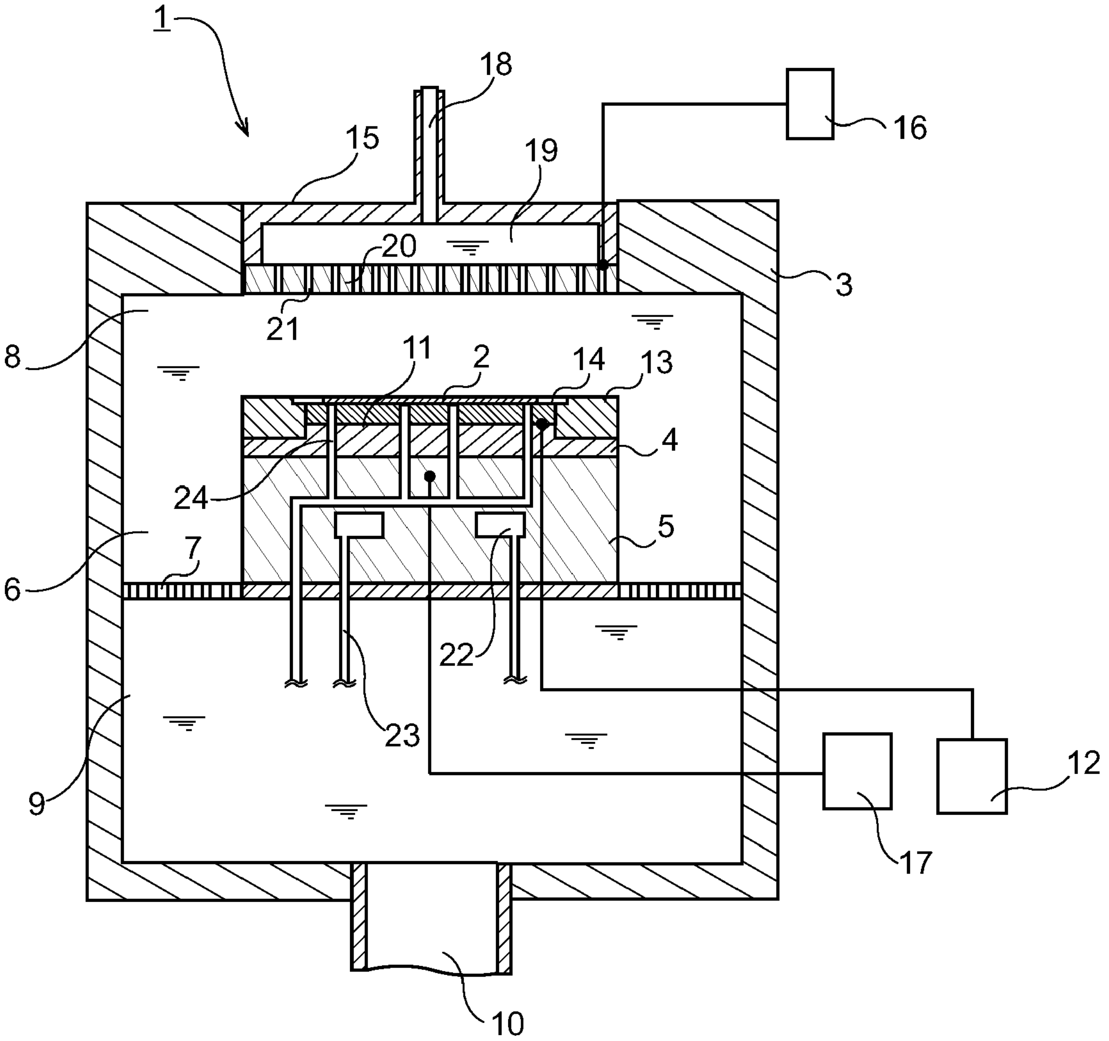


FIG. 1

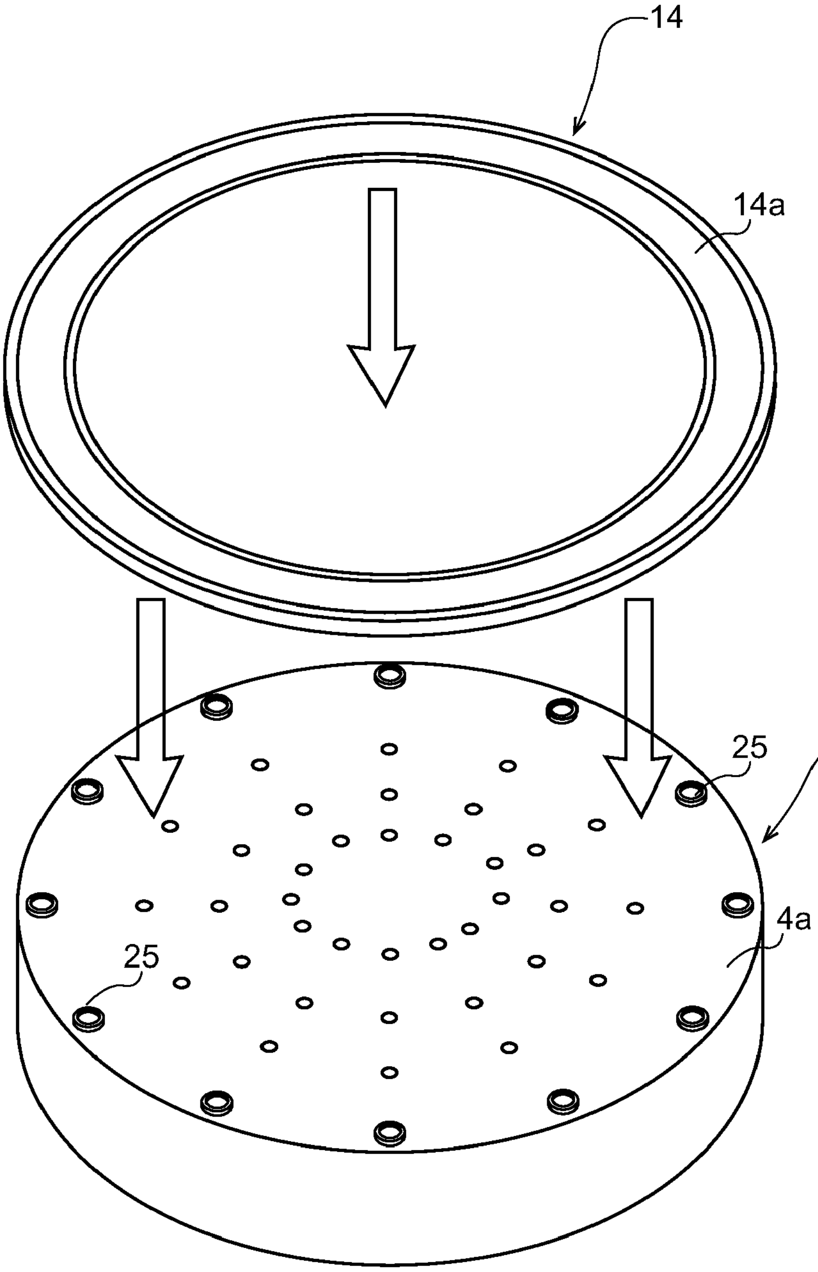


FIG. 2

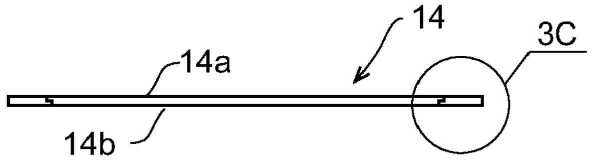


FIG. 3A

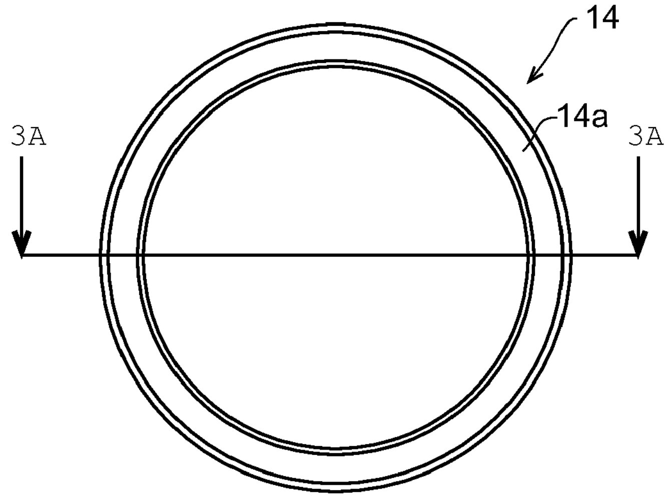


FIG. 3B

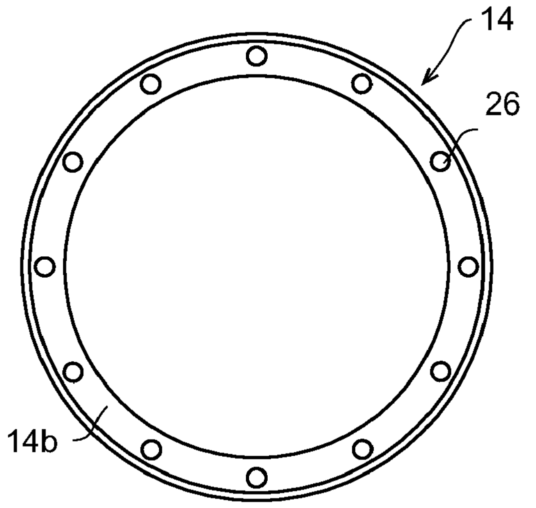


FIG. 3C

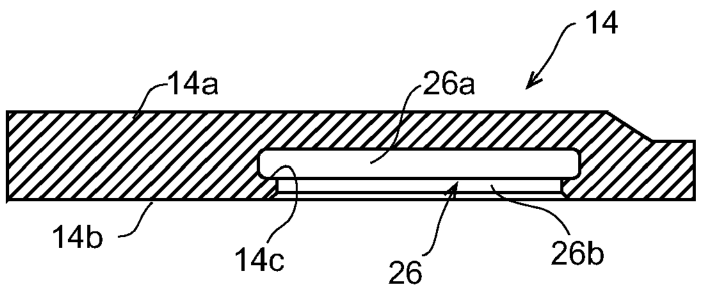


FIG. 3D

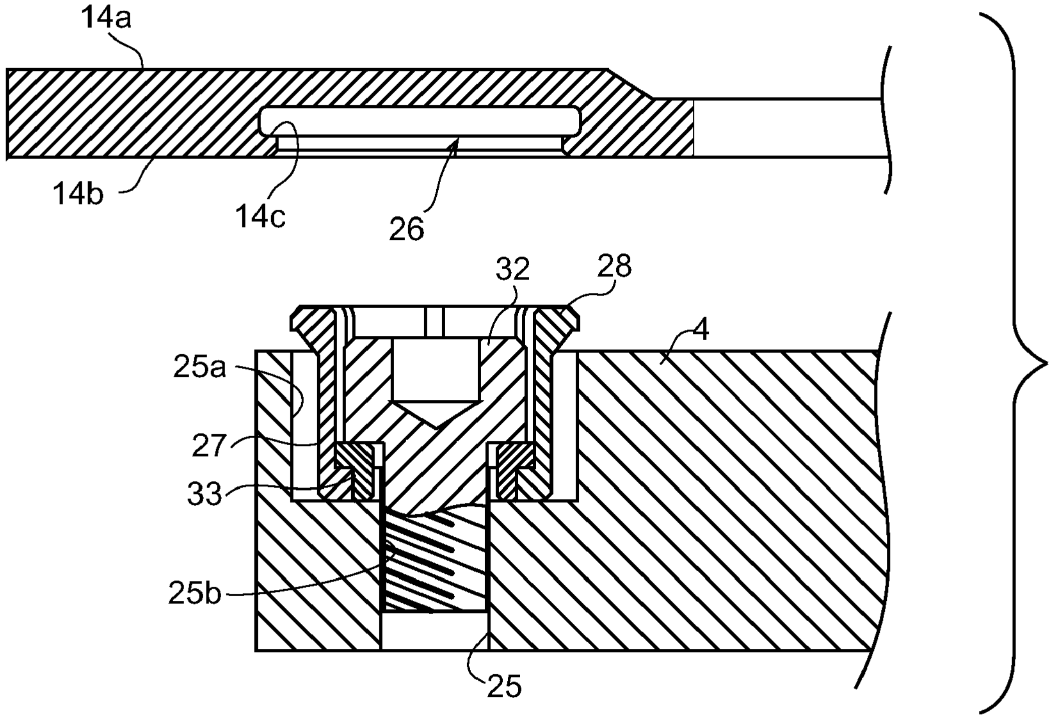
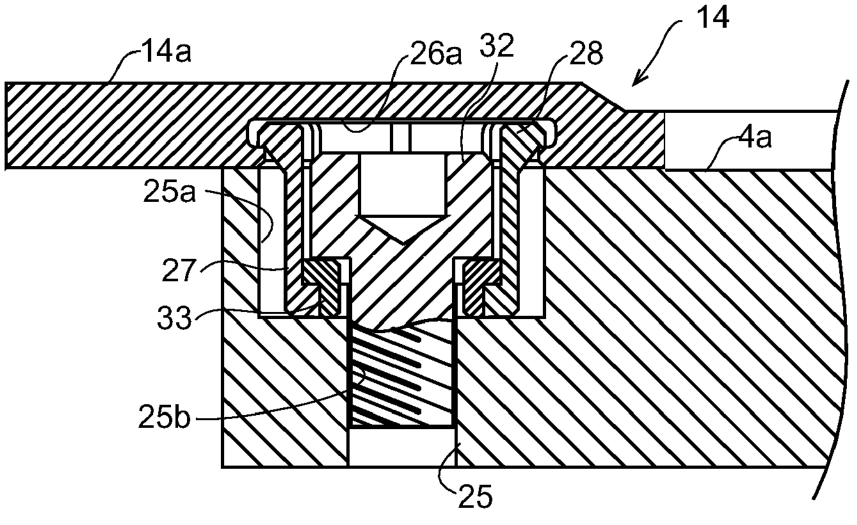

14a
14b
14c
26
32
28
4
25a
27
33
25b
25

FIG. 4A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14a
26a
32
28
4a
25a
27
33
25b
25

FIG. 4B

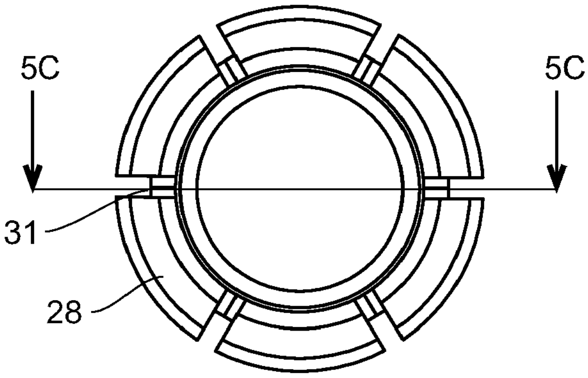

FIG. 5A

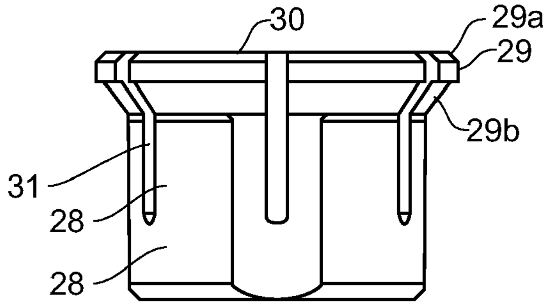

FIG. 5B

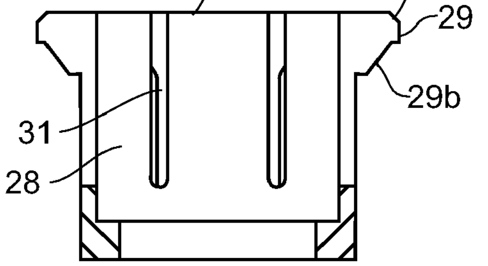

FIG. 5C

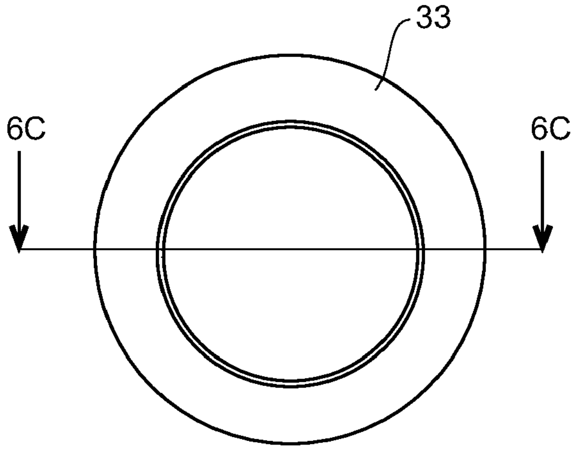

FIG. 6A

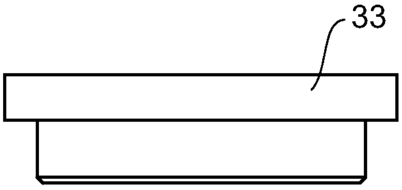

FIG. 6B

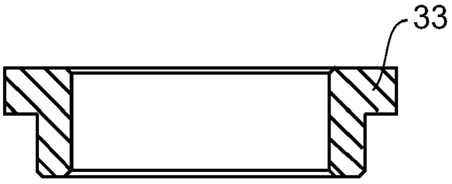

FIG. 6C

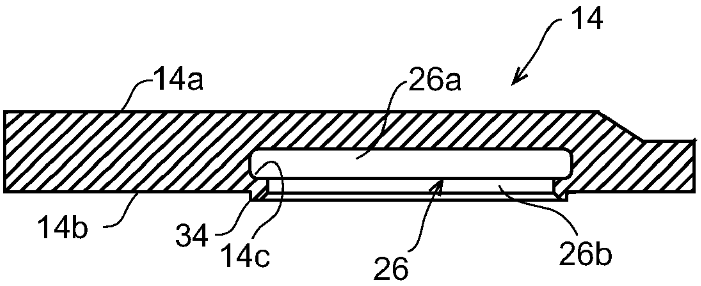

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/069511

A. CLASSIFICATION OF SUBJECT MATTER

H01L 21/687(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L 21/687; H01L 21/3065; H01L 21/311; B23B 31/28; C23C 16/54; H01L 21/683; C23F 1/08; C23C 16/00

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: clamping, ring-shaped, cooling, aperture and aligning

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012-0000605 A1 (KELLOGG et al.) 05 January 2012 See paragraphs [0006],[0010],[0029],[0032] and figures 3B,4B.	1,8-11
A		2-7
A	US 2011-0070740 A1 (BETTENCOURT et al.) 24 March 2011 See paragraphs [0010]-[0012] and claim 1.	1-11
A	US 2008-0268645 A1 (KAO et al.) 30 October 2008 See paragraphs [0012]-[0014] and figure 1.	1-11
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A	US 2006-0267294 A1 (BUSSE et al.) 30 November 2006 See claims 1,22 and figure 1.	1-11

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"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 18 February 2014 (18.02.2014)	Date of mailing of the international search report **18 February 2014 (18.02.2014)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. +82-42-472-7140	Authorized officer CHOI, Hyun Goo Telephone No. +82-42-481-8288

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