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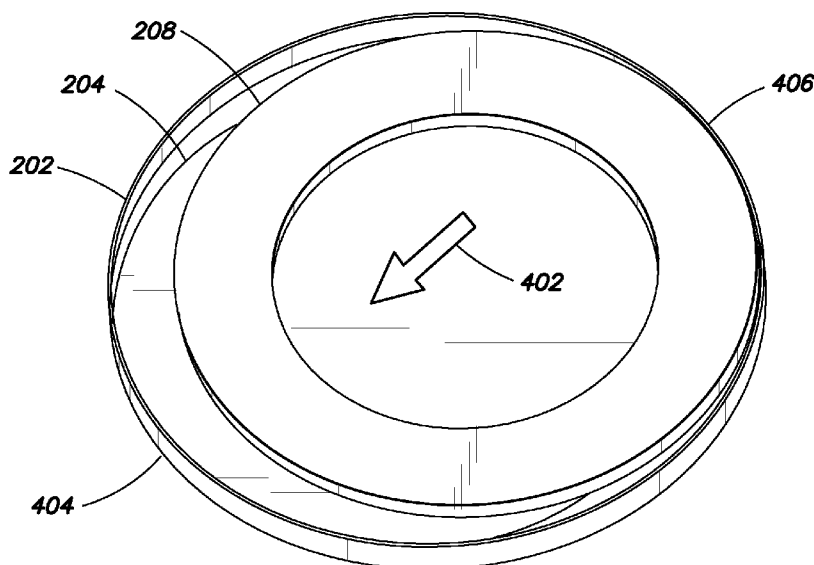
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TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
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(54) Title: METHODS AND APPARATUS FOR AN IMPROVED POLISHING HEAD RETAINING RING



(57) Abstract: Methods, apparatus, and systems are provided for retaining a substrate in a polishing head of a CMP system. The invention includes a flexible inner retaining ring adapted to contour to an edge of a substrate and an inner ring support coupled to the polishing head. The inner support ring is adapted to contact the flexible inner retaining ring in response to a side force load applied to the flexible inner retaining ring by a substrate being polished. Numerous additional aspects are disclosed.

**METHODS AND APPARATUS FOR AN IMPROVED
POLISHING HEAD RETAINING RING**

RELATED APPLICATIONS

[0001] The present application claims priority to and the benefit of U.S. Patent Application Serial No. 13/360,221, filed January 27, 2012, entitled "METHODS AND APPARATUS FOR AN IMPROVED POLISHING HEAD RETAINING RING" (Attorney Docket No. 16708/CMP/CMP/BOHN C).

FIELD

[0002] The present invention generally relates to electronic device manufacturing using chemical-mechanical planarization, and more particularly is directed to methods and apparatus for an improved polishing head retaining ring.

BACKGROUND

[0003] Chemical-mechanical planarization (CMP) systems use a polishing head to press and rotate a substrate against a polishing pad during processing. During the polishing process, a substrate in a polishing head is held within the head using a retaining ring, which encircles the substrate and prevents the substrate from being dragged out of the polishing head by the relative movement of the polishing pad. The inventors of the present invention have noticed that in some cases, the retaining ring may prematurely wear. Thus, what is

needed are improved methods and apparatus for retaining a substrate within a polishing head during processing.

SUMMARY

[0004] Inventive methods and apparatus are provided for retaining a substrate within a polishing head during processing. In some embodiments, the apparatus includes a flexible inner retaining ring adapted to contour to an edge of a substrate; and an inner ring support coupled to the polishing head and adapted to contact the flexible inner retaining ring in response to a side force load applied to the flexible inner retaining ring by a substrate being polished.

[0005] In some other embodiments, a polishing head system is provided. The polishing head system includes a flexible inner retaining ring adapted to contour to an edge of a substrate; an inner ring support coupled to the polishing head and adapted to contact the flexible inner retaining ring in response to a side force load applied to the flexible inner retaining ring by a substrate being polished; and a housing enclosing the flexible inner retaining ring and the inner ring support.

[0006] In yet other embodiments, a method of retaining a substrate in a polishing head during processing is provided. The method includes applying a side force to a substrate to be polished via a rotating polishing pad; contacting a flexible inner retaining ring with an edge of the substrate; and contouring the flexible inner retaining ring to the edge of the substrate by contacting the flexible inner retaining ring with an inner ring support coupled to the polishing head in

response to the side force being applied to the flexible inner retaining ring by the substrate being polished.

[0007] In still yet other embodiments, an alternate apparatus for retaining a substrate in a polishing head during processing is provided. The apparatus includes a flexible inner retaining ring adapted to contour to an edge of a substrate; and an outer retaining ring coupled to the polishing head and including a notch adapted allow the flexible inner retaining ring to flex in response to a side force load applied to the flexible inner retaining ring by a substrate being polished.

[0008] Numerous other aspects are provided. Other features and aspects of the present invention will become more fully apparent from the following detailed description, the appended claims and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 illustrates a diagram depicting a side view of an example chemical-mechanical planarization (CMP) system for polishing substrates according to embodiments.

[0010] FIG. 2 illustrates a schematic diagram depicting a side cross-sectional view of a polishing head of a CMP system according to embodiments.

[0011] FIG. 3 illustrates a schematic diagram depicting a partial side cross-sectional magnified view of a polishing head of a CMP system according to embodiments.

[0012] FIG. 4 illustrates a schematic diagram depicting a perspective view of a flexible inner retaining ring and an inner support of a polishing head of a CMP system according to embodiments.

[0013] FIG. 5 illustrates a schematic diagram depicting a cross-sectional perspective view of a flexible inner retaining ring and an inner support of a polishing head of a CMP system according to embodiments.

[0014] FIG. 6 illustrates a schematic diagram depicting a partial cross-sectional perspective view of a flexible inner retaining ring and a notched outer retaining ring of a polishing head of a CMP system according to alternate embodiments.

[0015] FIG. 7 illustrates flowchart depicting an example method of retaining a substrate in a polishing head of a CMP system according to embodiments.

[0016] FIG. 8 illustrates a schematic diagram depicting a conventional polishing head retaining ring design according to the prior art.

DETAILED DESCRIPTION

[0017] The present invention provides methods and apparatus for an improved retaining ring of a polishing head of a chemical-mechanical planarization (CMP) system. Referring to FIG. 8, during the polishing process in a conventional CMP system, the substrate 802 inside of a polishing head 800 comes into contact with a retaining ring. In some systems, the retaining ring is a one-piece design and, in others, the retaining ring includes two pieces: an outer ring 804 and an inner ring 806 as shown in FIG. 8. In either of these designs, the substrate 802 has a smaller diameter than the retaining ring 806. In operation, the rotation of the polishing pad pushes the substrate 802 against the retaining ring 806. The lateral force applied to the substrate 802 by the polishing pad and against the retaining ring 806 by the substrate 802 is referred to as "side force" 808. The polishing head applies a downward force on the substrate that pushes the substrate against the polishing pad referred to as "membrane pressure." The polishing head also applies a rotational force to the substrate.

[0018] As a result of the side force 808 in a conventional polishing head 800, a point contact 810 is realized between the substrate 802 and the inside surface of the retaining ring 806. This focused load places a large amount of stress on the retaining ring 806. Further, with larger substrates, at any given membrane pressure, the side force of the substrate against the retaining ring is increased. The inventors of the

present invention have determined that at larger substrate sizes with larger membrane pressures, this focused force would create unacceptable localized stress levels within the retaining ring leading to component failure.

[0019] Embodiments of the present invention use a flexible inner retaining ring to support and distribute the substrate's side force load. This increases the contact area of the substrate on the retaining ring by allowing the flexible inner retaining ring to contour to the substrate's edge. As a result of the increased contact area, the side force load is distributed over a larger area and lower stress levels on the retaining ring are achieved. With the larger diameter substrates and larger polishing pressures, the present invention thus reduces the likelihood of component failure from unacceptably high material stress.

[0020] Turning to FIG. 1, a side view of an example chemical-mechanical planarization (CMP) system 100 for polishing substrates is shown. The system 100 includes a load cup assembly 102 for receiving a substrate to be polished and for holding the substrate in place for a polishing head 104 to pick up. The polishing head 104 is supported by an arm 106 that is operative to move the head 104 between the load cup assembly 102 and a polishing pad 108 on a rotating platen 110. In operation, the head 104 picks up the substrate from the load cup assembly 102 and carries it to the polishing pad 108. As the polishing pad 108 is rotated on the platen 110, the head 104 rotates and pushes the substrate down against the

polishing pad 108. Note that the diameter of the polishing pad 108 is more than twice that of the substrate.

[0021] Turning to FIGs. 2 and 3 which depict some details of the polishing head 104 in a cross-sectional view and a magnified, partial cross-sectional view respectively, the flexible inner retaining ring 202 extends down from the polishing head 104 to surround and retain the substrate 204 during polishing. The outer retaining ring 206 surrounds the inner ring 202 and an inner ring support 208 is disposed within the inner ring 202 and above the level of the substrate 204. The polishing head 104 includes a housing 210 that encloses the other components, a spindle for rotating the head 104, and also means for holding a substrate such as a bladder, a suction system, or other chucking devices.

[0022] Turning now to FIGs. 4 and 5, the lower portion of a flexible inner retaining ring 202 and an inner ring support 208 of a polishing head 104 (FIG. 3) are shown relative to a substrate 204. The inner ring support 208 is disposed above the substrate 204 and is rigidly attached to the polishing head 104 (FIG. 3).

[0023] As shown in the perspective view of FIG. 4 and the cross-sectional perspective view of FIG. 5, as the side force 402 is applied to the substrate 204 (by the rotation of the polishing pad 108 (FIG. 1)), the edge of the substrate 204 presses against the inside of the flexible inner retaining ring 202 at point 404. This causes the flexible inner retaining ring 202 to pull against the inner ring support 208

at point 406. Note that point 404 is on the opposite side of the flexible inner retaining ring 202 of point 406.

[0024] These forces distort the flexible inner retaining ring 202 into an oval shape with a portion of the flexible inner retaining ring 202 contacting and contouring to the edge of the substrate 204. This contouring of the flexible inner retaining ring 202 increases the amount of contact between the substrate 204 and the flexible inner retaining ring 202. This results in the stress of the side force 402 being distributed over a larger area and avoids concentrated stresses that might otherwise lead to failure of the retaining ring.

[0025] In some embodiments, the flexible inner retaining ring 202 may be constructed of Techtron PPS, Ertalyte PET-P, or Ketron PEEK material manufactured by Quadrant Corporation located in Reading, PA, USA. Other practicable flexible materials may be used. The approximate thickness of the flexible inner retaining ring 202 may be in the range of approximately 1 mm to approximately 5 mm for retaining 300 mm size substrates. For larger substrates, a thicker flexible inner retaining ring 202 may be used.

[0026] In some embodiments, the flexible inner retaining ring 202 may have a diameter of approximately 301 mm to approximately 310 mm for retaining 300 mm size substrates. For larger substrates, a larger diameter flexible inner retaining ring 202 may be used. In some embodiments, the inner ring support 208 may have a diameter of approximately 300 mm to approximately 309 mm for retaining 300 mm size

substrates. For larger substrates, a larger diameter inner ring support 208 may be used.

[0027] Turning now to FIG. 6, an alternative embodiment of the present invention is shown. Instead of using an inner ring support 208 as in the embodiment of FIGs. 4 and 5, this alternative embodiment includes an outer ring 602 that has a notch 604 in the lower, inner surface proximate to where the substrate contacts the flexible inner retaining ring 202' as shown in FIG. 6. This arrangement allows the flexible inner retaining ring 202' to flex and to be pushed into the notch by the side force 402 from the substrate 204.

[0028] In some embodiments, the flexible inner retaining ring 202' of this embodiment may be constructed of Techtron PPS, Ertalyte PET-P, or Ketron PEEK material manufactured by Quadrant Corporation located in Reading, PA, USA. Other practicable flexible materials may be used. The approximate thickness of the flexible inner retaining ring 202' may be in the range of approximately 1 mm to approximately 10 mm for retaining 300 mm size substrates. For larger substrates, a thicker flexible inner retaining ring 202' may be used.

[0029] In some embodiments, the outer ring 602 of this embodiment may be constructed of Techtron PPS, Ertalyte PET-P, or Ketron PEEK material manufactured by Quadrant Corporation located in Reading, PA, USA. Other practicable materials may be used. The approximate depth and height of the notch may be in the range of approximately 1 mm to approximately 10 mm for retaining 300 mm size substrates. For larger substrates, a

notch of different dimensions may be used. In some embodiments, differently shaped notches may be used.

[0030] Turning now to FIG. 7, an example method 700 of retaining a substrate in a polishing head 104 during processing is depicted in a flowchart. In step 702, a side force 402 is applied to a substrate 204 to be polished via a rotating polishing pad. In step 704, a flexible inner retaining ring 202 is contacted by an edge of the substrate 204. In step 706, the flexible inner retaining ring 202 is contoured to the edge of the substrate 204. This is done by contacting the flexible inner retaining ring 202 with an inner ring support 208 coupled to the polishing head 104 in response to the side force 402 being applied to the flexible inner retaining ring 202 by the substrate 204 being polished. The side force 402 is generated by friction from the polishing pad 108 rotating against the substrate 204.

[0031] In some embodiments, the inner ring support 208 contacts the flexible inner retaining ring 202 at least at a point 406 on the flexible inner retaining ring 202 opposite a point 404 that the substrate 204 contacts the flexible inner retaining ring 202. The inner ring support 208 is disposed above the substrate 204 within a circumference of the flexible inner retaining ring 202 and thus, the inner ring support 208 has a diameter smaller than the flexible inner retaining ring 202. In some embodiments, the polishing head 104 may also include an outer retaining ring 206 coupled to the polishing head 104 and disposed around the flexible inner retaining ring 202.

[0032] Accordingly, while the present invention has been disclosed in connection with the preferred embodiments thereof, it should be understood that other embodiments may fall within the scope of the invention, as defined by the following claims.

CLAIMS**THE INVENTION CLAIMED IS:**

1. An apparatus for retaining a substrate in a polishing head, the apparatus comprising:

a flexible inner retaining ring adapted to contour to an edge of a substrate; and

an inner ring support coupled to the polishing head and adapted to contact the flexible inner retaining ring in response to a side force load applied to the flexible inner retaining ring by a substrate being polished.

2. The apparatus of claim 1 wherein the inner ring support contacts the flexible inner retaining ring at least at a point on the flexible inner retaining ring opposite a point that the substrate contacts the flexible inner retaining ring.

3. The apparatus of claim 1 wherein the inner ring support is disposed above the substrate within a circumference of the flexible inner retaining ring.

4. The apparatus of claim 1 wherein the inner ring support has a diameter smaller than the flexible inner retaining ring.

5. The apparatus of claim 1 further comprising an outer retaining ring coupled to the polishing head and disposed around the flexible inner retaining ring.

6. A polishing head system for a chemical-mechanical planarization (CMP) tool, the polishing head system comprising:

a flexible inner retaining ring adapted to contour to an edge of a substrate;

an inner ring support coupled to the polishing head and adapted to contact the flexible inner retaining ring in response to a side force load applied to the flexible inner retaining ring by a substrate being polished; and

a housing enclosing the flexible inner retaining ring and the inner ring support.

7. The system of claim 6 wherein the inner ring support contacts the flexible inner retaining ring at least at a point on the flexible inner retaining ring opposite a point that the substrate contacts the flexible inner retaining ring.

8. The system of claim 6 wherein the inner ring support is disposed above the substrate within a circumference of the flexible inner retaining ring.

9. The system of claim 6 wherein the inner ring support has a diameter smaller than the flexible inner retaining ring.

10. The system of claim 6 further comprising an outer retaining ring coupled to the polishing head and disposed around the flexible inner retaining ring.

11. A method of retaining a substrate in a polishing head, the apparatus comprising:

applying a side force to a substrate to be polished via a rotating polishing pad;

contacting a flexible inner retaining ring with an edge of the substrate; and

contouring the flexible inner retaining ring to the edge of the substrate by contacting the flexible inner retaining ring with an inner ring support coupled to the polishing head in response to the side force being applied to the flexible inner retaining ring by the substrate being polished.

12. The method of claim 11 wherein the inner ring support contacts the flexible inner retaining ring at least at a point on the flexible inner retaining ring opposite a point that the substrate contacts the flexible inner retaining ring.

13. The method of claim 11 wherein the inner ring support is disposed above the substrate within a circumference of the flexible inner retaining ring.

14. The method of claim 11 further comprising disposing an outer retaining ring coupled to the polishing head around the flexible inner retaining ring.

15. An apparatus for retaining a substrate in a polishing head, the apparatus comprising:

a flexible inner retaining ring adapted to contour to an edge of a substrate; and

an outer retaining ring coupled to the polishing head and including a notch adapted to allow the flexible inner retaining ring to flex in response to a side force load applied to the flexible inner retaining ring by a substrate being polished.

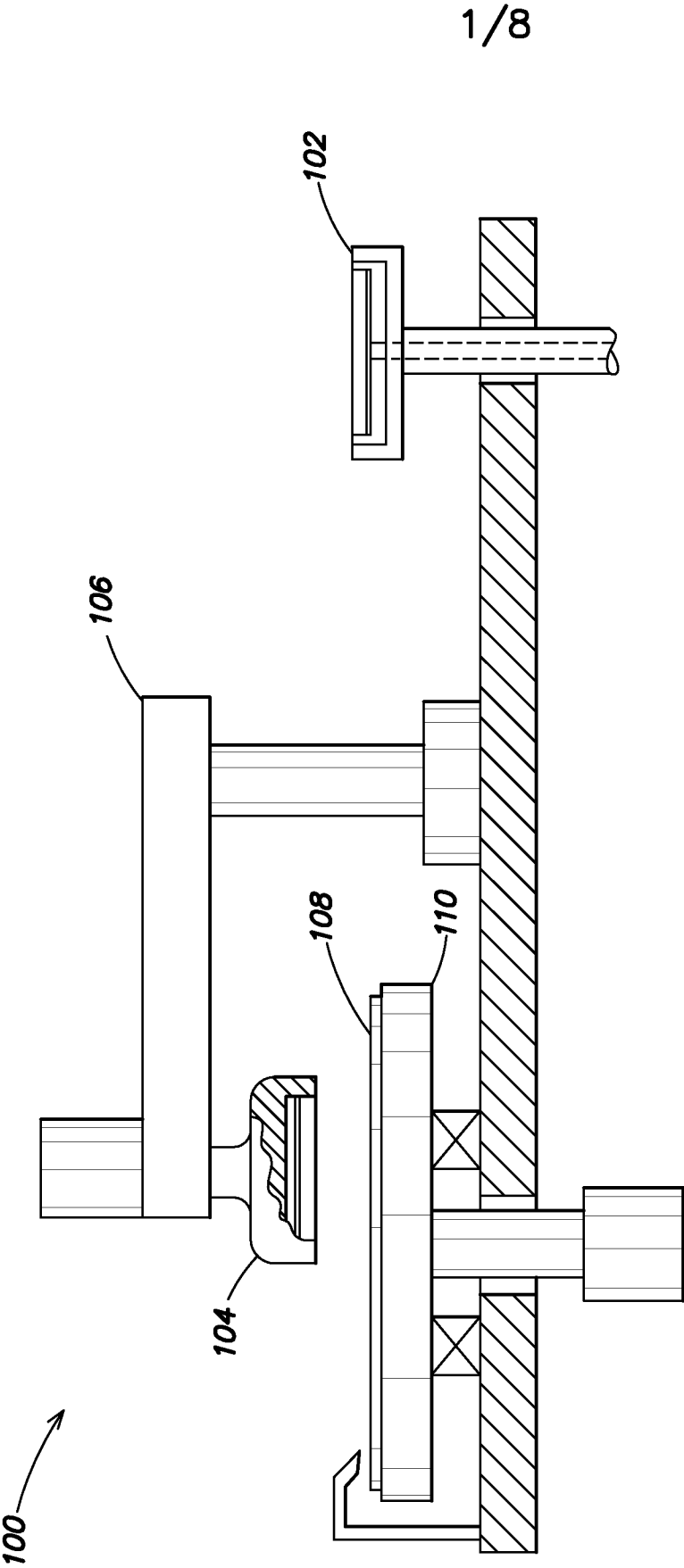


FIG. 1

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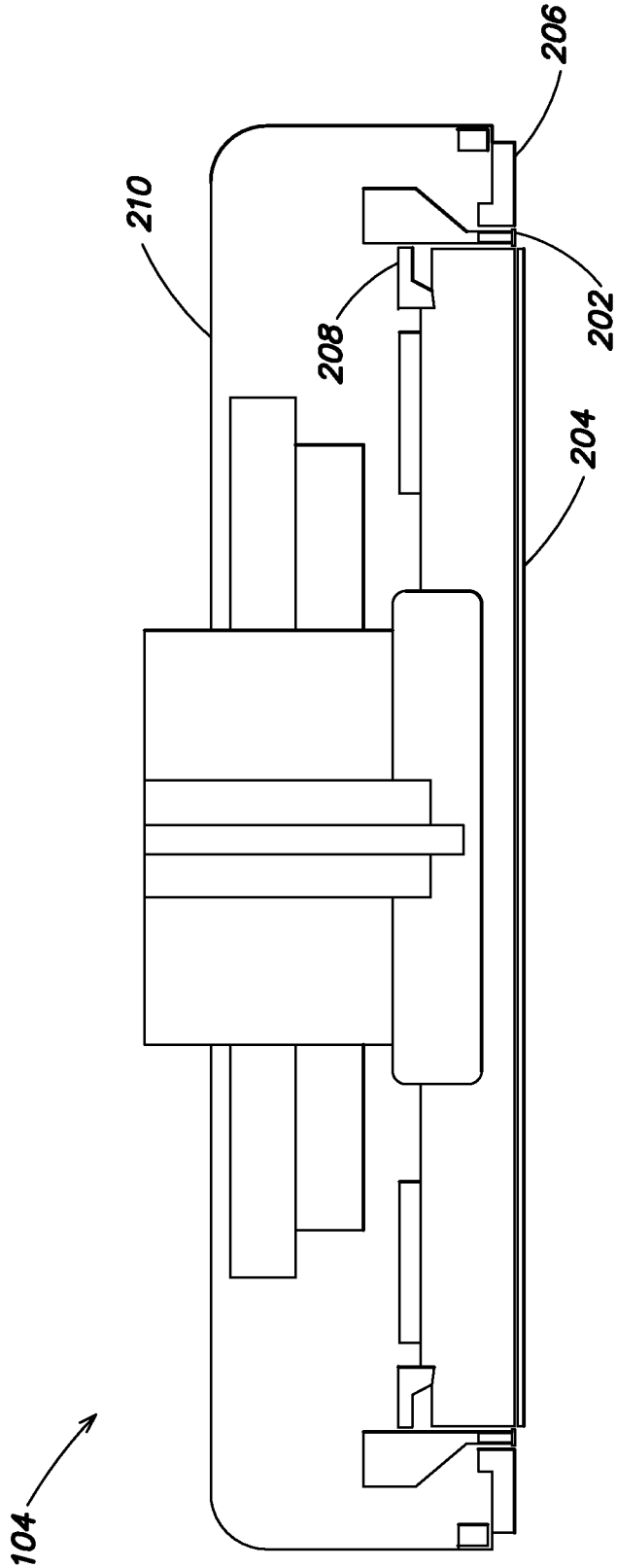


FIG. 2

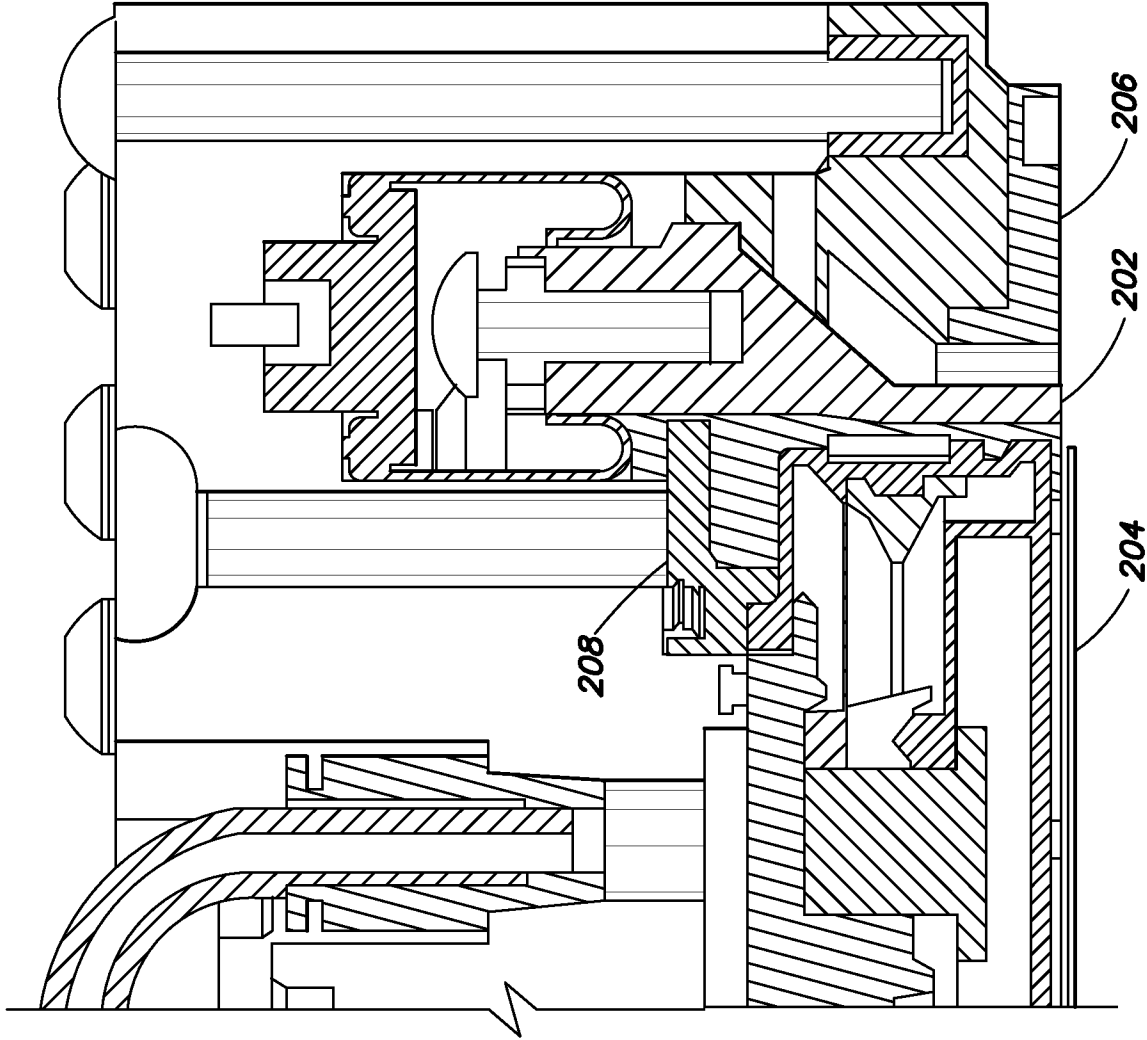


FIG. 3

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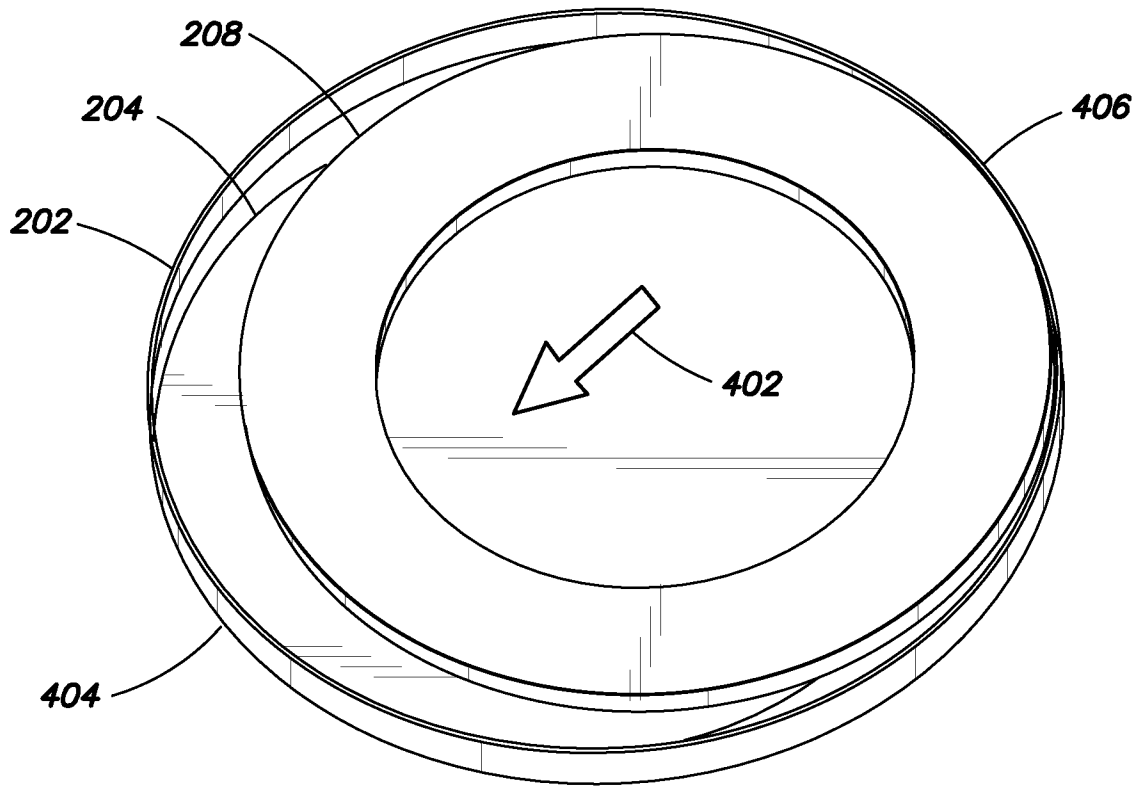


FIG. 4

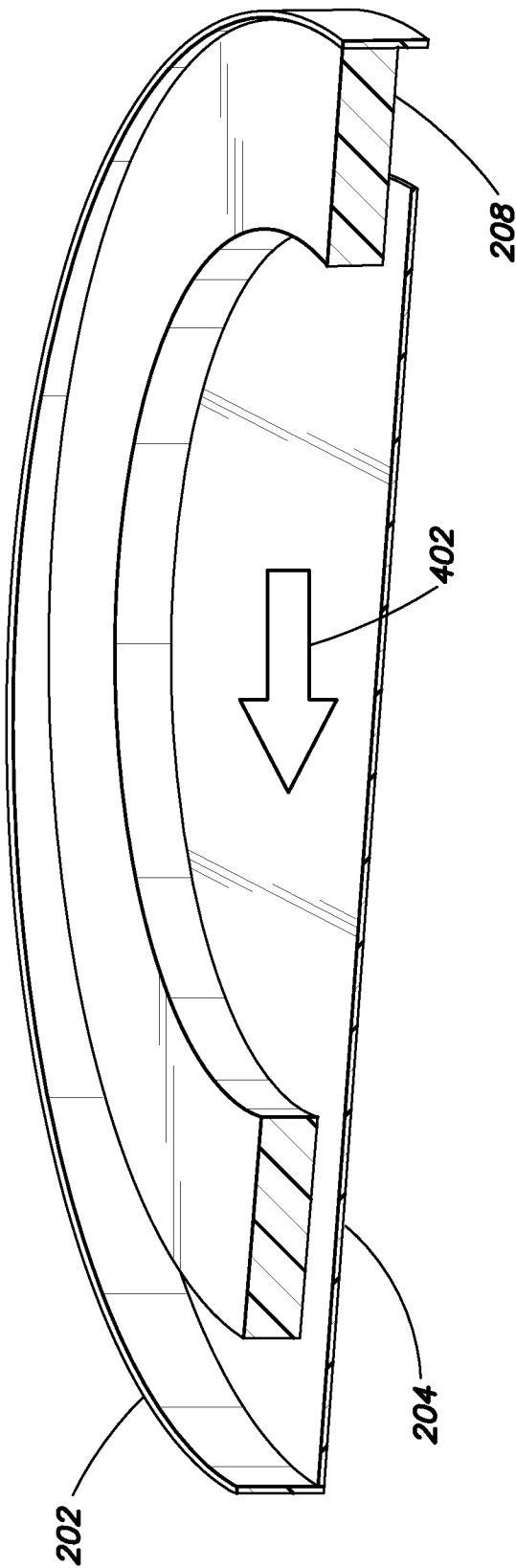
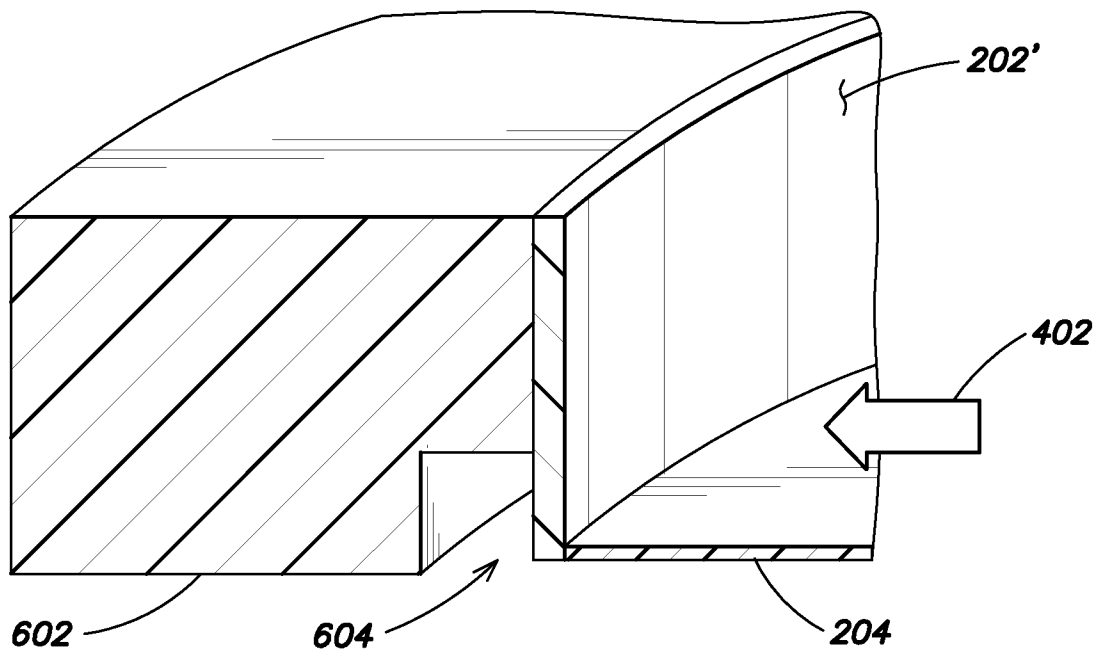
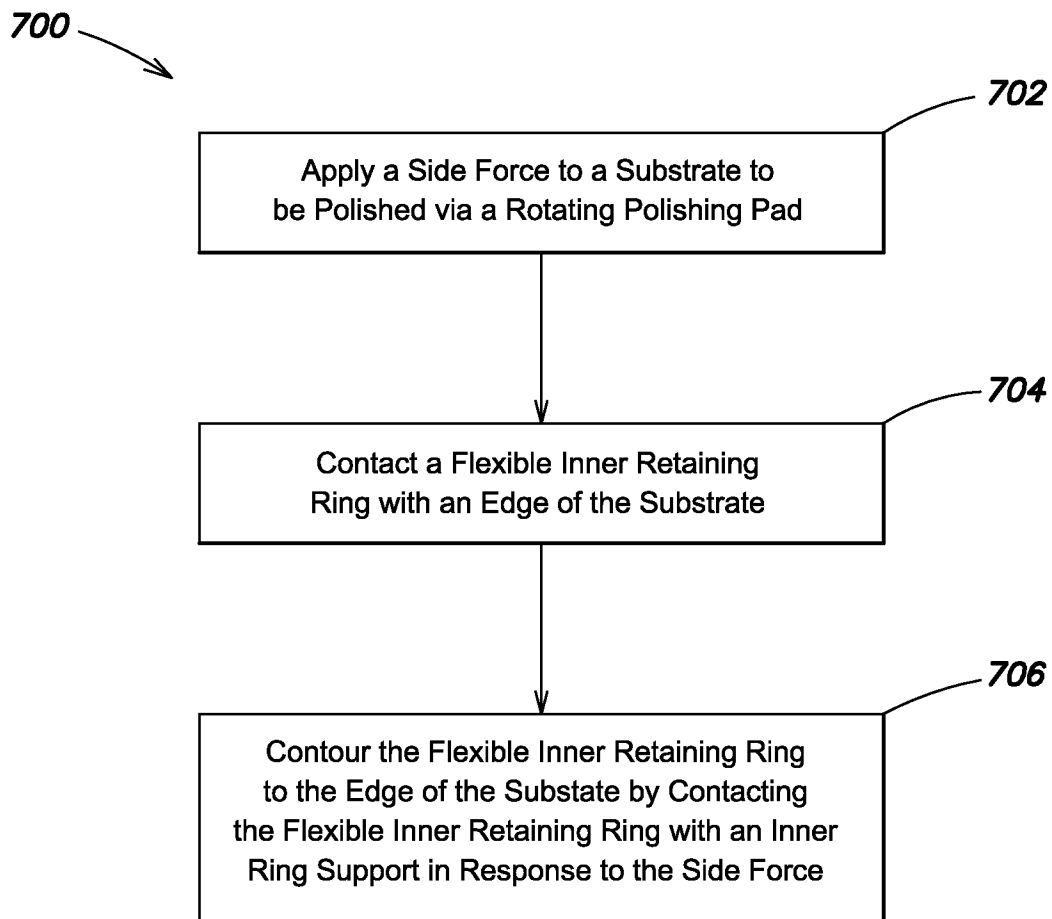


FIG. 5

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**FIG. 6**

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**FIG. 7**

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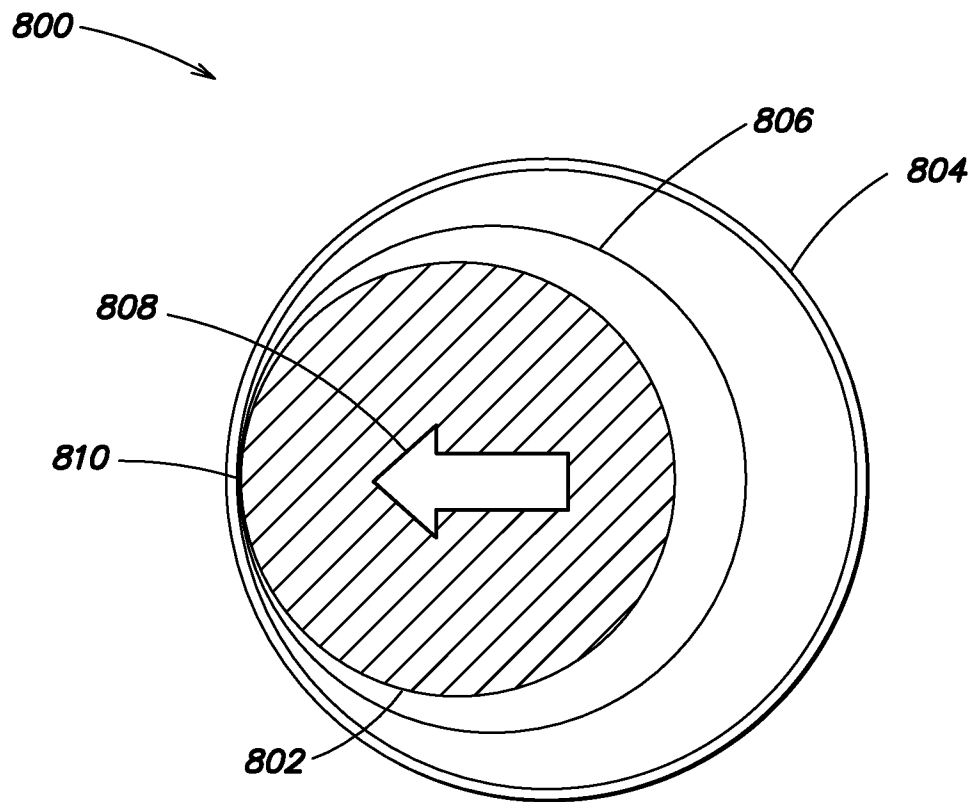


FIG. 8
(Prior Art)

A. CLASSIFICATION OF SUBJECT MATTER***B24B 37/32(2012.01)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)

B24B 37/32; H01L 21/304; B24B 47/02; C23F 1/00; B24B 7/00; B24B 37/04; B24B 1/00

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: retaining ring, substrate, flexible, contour, contact, side force, polish, CMP, inner, outer, and support

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	US 2009-0111362 A1 (NABEYA et al.) 30 April 2009 See paragraphs [0009],[0082]-[0084], claim 1, and figures 2,7,8.	1-14 15
Y	JP 2010-040604 A (TOKYO SEIMITSU CO., LTD.) 18 February 2010 See abstract, paragraphs [0009],[0031],[0032], claim 1, and figures 3a,3b.	1-14
Y	US 6890249 B1 (ZUNIGA et al.) 10 May 2005 See abstract, claim 1, and figure 2.	5,10,14
A	US 2005-0037698 A1 (ZUNIGA et al.) 17 February 2005 See paragraphs [0056]-[0058], claim 1, and figure 4A.	1-15
A	US 2008-0066862 A1 (GUNJI et al.) 20 March 2008 See paragraphs [0044],[0045], claim 38, and figure 1.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

26 April 2013 (26.04.2013)

Date of mailing of the international search report

29 April 2013 (29.04.2013)

Name and mailing address of the ISA/KR

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Facsimile No. 82-42-472-7140

Authorized officer

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Telephone No. 0424818398



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2013/021399**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

- I . Claims 1-14 are directed to an apparatus comprising a flexible inner retaining ring and an inner ring support.
- II . Claim 15 is directed to an apparatus comprising a flexible inner retaining ring and an outer retaining ring including a notch.

The only common technical feature among claims 1-14 and 15 is a flexible inner retaining ring. However, this feature lacks novelty and/or inventive step with respect to the following document cited in this ISR:

(a) JP 2010-040604 A

Thus, there is no technical relationship left over the prior art among the claimed inventions, leaving the Claims without a single general inventive concept. Hence, there is lack of unity "a posteriori"(PCT Rules 13.1 and 13.2).

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/021399

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