

WAFER CONTAINER WITH OVERLAPPING WALL STRUCTURE

FIELD OF THE INVENTION

This invention relates to improvements in a container for the transportation of semiconductor wafers. More particularly, the present wafer container includes
5 improvements in side protection to the wafers, improved cover design to minimize rotation, a simplified top cover orientation mechanism and an improved bottom holding mechanism for automation.

DESCRIPTION OF RELATED ART

In the processing of semiconductor wafers the typically must be transported
10 either between processes or to other facilities. The semiconductor wafers are fragile and damage to the surface of the wafers can make the wafer useless for the intended purpose. Because of the high potential for damage to the wafer the semiconductors must be packaged and transported to minimize harm. In transportation, multiple semiconductor wafers are stacked into a transportation container. There have been a
15 number of containment products and patents have been sold and patented to try and minimize damage to these silicon wafers. Exemplary examples of patents covering these products are disclosed herein.

U.S. Patent Number 6,193,068 issued February 27, 2001 to Lee Lewis et al., and 6,341,695 issued January 29, 2002 to Lee Lewis et al., disclose a containment
20 device for retaining semiconductor wafers. This patent discloses two concentric walls on the top and bottom housings that nest to protect the semiconductor wafers. Double walls were designed to protect the wafers from the direct transmission of forces that may contact the outer wall. While the nesting walls provide protection from side impacts they do not provide flexibility to absorb and cushion a side impact or drop.
25 The combination of an outer wall and a gap provide the protection. Damage may also occur if the force is such that the outer wall flexes enough to interfere with the inner wall, thereby damaging the wafers. That can cause the semiconductor wafers to shift and scratch.

U.S. Patent Publication Number US2009/0095650 that was published on April 16, 2009 to James D. Pylant et al., discloses a wafer container with staggered wall structure. In this published application the design is limited by the amount overlap of the inner and outer walls by the design of its staggered walls. The walls were limited
5 to 5% overlap, with 95 percent of the outer wall not located in adjoining angular sectors. This and other top cover rotation locating mechanisms use either an inner surface of a feature on the top cover or an exterior surface of a feature on the top cover to secure the top cover in place and prevent rotation.

U.S. Patent Number 6,550,619 issued April 22, 2003 to Gregory W. Bores et al., discloses a shock resistant variable load tolerant wafer shipper. This patent uses
10 four inner tapered walls with a variable amount of cushions placed between the semiconductor wafers to pack and cushion the semiconductor wafer. While this patent allows for a variable amount of semiconductor wafers to be packed within the shipper the cushioning relies on the variable amount of cushions placed between the
15 semiconductor wafers to reduce damage.

U.S. Patent Number 7,040,487 issued on May 9, 2006 to Michael Zabka et al., discloses a protective shipper with a corrugated inner containment lip. The corrugated inner lip provides multiple surfaces for the edges of the semiconductor wafers to make contact with, but because the edges are corrugated the tangential walls of the
20 corrugation limit the flexing of the inner lips.

Some semiconductor wafer containers use a rotation locking design where the locating mechanism with an exclusive inner surface or exterior surface do not securely capture the wall that they are adjacent to in both directions of rotation. These features only stop rotation in only one direction. The features must rely on a sister
25 feature to stop rotation in the opposite direction which is generally located farther away and allows for more manufacturing tolerance to build up since it is located at a greater distance. These deficiencies result in larger gaps between the plus and minus rotational limiting surfaces, thereby leading to more rotational movement.

There are a number of prior designs that use top cover orientation features with differing wall engagement angles or large latches as opposed to small slots. The new feature in this proposed wafer container allows improved orientation that is not found in the prior art.

5 There are a number of different holding and clamping features in wafer shipping containers. All of these prior designs rely on multiple parts to create a clamping lip. These designs have several drawbacks including but not limited to the parts not being rigid with respect to the bottom assembly because they must be sonic welded, bonded or snapped together and that secondary parts or assembly operations
10 are more expensive to produce.

The engagement of latches that secure the top and bottom housings together have a number of limitations. Specifically, prior art latches provide a raised straight slope ramp. The raise straight sloped surface is susceptible to damage and also, the straight slope does not provide an ideal self gripping to engage between the top and
15 bottom housings. The top cover orientation features use differing wall engagement angles or large latches as opposed to small slots as presented in this pending application.

What is needed is a semiconductor wafer container with improvements in side protection to the wafers, improved cover design to minimize rotation, a simplified top
20 cover orientation mechanism and an improved bottom holding mechanism for automation. This pending application satisfies these requirements with novel improvements in the identified areas.

BRIEF SUMMARY OF THE INVENTION

The invention is defined in the independent claim. Some optional features of the invention are defined in the dependent claims. An exemplary semiconductor wafer container has an overlapping double wall. The wall structure may comprise multiple outer walls and multiple inner walls. The overlapping double containment wall may increase semiconductor wafer protection during impact or shipping. Each inner wall may share a minimal percentage of a common angular sector with each adjacent outer wall. The inner wall may be generally very stiff and does not absorb and cushion the wafers if the container is dropped or subject to impact. On the bottom assembly, the inner walls and outer walls may be positioned in an offset and overlapping configuration to provide maximum protection to the semiconductor wafers.

An exemplary semiconductor wafer container improves alignment of the top cover with the base. The alignment system may include reference tabs that are received by the cover and a visual identifier for guiding an operator in the proper alignment of the two halves of the container. The top cover orientation features may prevent improper installation of the top cover to the bottom member. The top cover orientation feature may be incorporated into the top cover that mates with the features of the double locking location feature. This orientation feature may prevent installation of the top cover in plus or minus 90 degree locations about the central axis.

An exemplary semiconductor wafer container may provide an improved locking mechanism for securing two halves of a wafer container together. The bottom half may comprise a wall structure perpendicular to the base. The wall structure may comprise segmented inner and outer walls, where each portion of the wall structure has a distinctive arc length. The arc length of each inner wall may not completely overlap with the arc length of any outer wall.

An exemplary semiconductor wafer container may provide an improved engagement feature for the locking tabs. These improved tabs may include a cover for a wafer container that engages to a base. The cover may include one or more notches, each having a ramp that easily receive latches from the base.

5 An exemplary semiconductor wafer container may incorporate bi-directional rotation locking feature(s). These features may improve orienting, the top member on the bottom member that decreases the amount of top cover rotation and movement with respect to the bottom member. This feature may create a double locking location that securely locates and locks the top cover in place during top cover assembly. The bi-directional rotation locking feature may be located on both sides of the perpendicular top cover surfaces of a single wall on both the interior and the exterior simultaneously. 10 This improvement may provide bi-directional locking of the captured surface decreases the amount of top cover rotation and movement with respect to the bottom member and increases the rigidity of the containment device when the members are assembled.

15 An exemplary semiconductor wafer container includes an improved holding and clamping feature to allow for automated machinery to latch onto and hold the bottom member and secure it firmly to the machinery nesting locations. This mechanism may be comprise of a single piece feature that is molded into the bottom member. The holding and clamping feature on the bottom member may improve equipment interface where these containers are used. The feature may be holding 20 mechanism to allow for automated machinery to latch onto and hold the bottom member and secure it firmly to the machinery nesting locations.

25 An exemplary semiconductor wafer container may include an improved curved latch recess for improved closure and retention of the containment device latches. In the improved latch and latch recess the height of the latch may be equal to or lower than the inner wall structure. This may allow equipment to interface with the bottom member of the container without interference with the equipment and latch height. A curvature on the mating surface may provide superior holding and self centering and gripping 30 during handling and after impact. This recessed feature may also protect the mating surface from damage when the top cover is disassembled from the bottom member. The latch recess and curved surface may also provide increased latch retention and container integrity during impact or shipping. This may include a lowered latch 35 equal to or less than the inner wall height.

Various objects, features, aspects, and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments of the invention, along with the accompanying drawings in which like numerals represent like components.

5 **BRIEF DESCRIPTION OF DRAWINGS**

FIG. 1 shows a perspective exploded view of the wafer container with a plurality of wafers disposed between the two wafer container halves.

FIG. 2 shows a top view of the bottom housing with the overlapping rib wall pattern.

10 FIG. 3 shows a detailed perspective view of the overlapping inner rib walls.

FIG. 4 shows a top view of the bi-directional locking feature in the bottom housing.

FIG. 5 shows a perspective view of the bi-directional locking feature on the bottom housing.

15 FIG. 6 shows a perspective view of the bi-directional locking feature on the top housing.

FIG. 7 shows an inside plan view of the top housing showing the orientation features.

20 FIG. 8 shows inside plan view of the bottom housing showing the orientation features.

FIG. 9 shows a detail perspective view of the orientation key in the top housing.

FIG. 10 shows a detail perspective view without the orientation key in the top housing

25 FIG. 11 shows a detail perspective view of the clearance for the orientation key in the bottom housing.

FIG. 12 shows a detail perspective view of the interference for the orientation key in the bottom housing.

FIG. 13 shows a top perspective view of the bottom housing.

30 FIG. 14 shows a detailed perspective view of the hold down latch.

FIG. 15 shows a perspective cross section of the hold down latch.

FIG. 16 shows a perspective view of the top and bottom latch tab engaged.

FIG. 17 shows a side view of the bottom latch tab.

FIG. 18 shows a sectional view of the latch engaged between the top and
5 bottom housings.

FIG. 19 shows a detailed view of the engaged between the top and bottom
housings.

FIG. 20 shows a perspective view of the top and bottom housings in an open
exploded view for reference of the internal components.

10 DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a perspective exploded view of the wafer container with a plurality of wafers disposed between the two wafer container clam shells. A plurality of semiconductor wafers 20, 21 and 22 are shown between the top 50 and bottom 100 housing with wafer separators 25. The inside base surface 102 extends to the outside
15 of the base surface 103 where the bottom housing has a ribbed pattern 101 that supports the bottom of the bottom most semiconductor wafer 20 and provides increased structural strength to the fairly plainer base surface 102 and 103. Both the top 50 and the bottom housings 100 have essentially planar rectangular or square bases. A plurality of inner rib walls 110 and 111 of the bottom housing 100 protect
20 the semiconductor wafers from shifting side damage. These walls can flex to cushion side impact. They are formed in a segmented pattern in the bottom housing. The segmented ribs are shown and described in more detail with figure 2. A second set of segmented outer ribs 112 and 113 exist outside of the inner rib walls 110 and 111. The rib walls exist in an overlapped 120 and 121 pattern to prevent debris from
25 passing directly through the segmented ribs.

FIG. 2 shows a top view of the bottom housing with the overlapping rib wall pattern. Note that some features, such as bottom ribs, have been deleted from the bottom surface 102 and 103 and the overlapping ribs have been moved slightly to improve clarity of the overlapping rib features being discussed herein. FIG. 3 shows a detailed perspective view of the overlapping inner rib walls. While in Figures 2 and 3 only one section of overlapping ribs is identified, the overlapping condition exists in eight places in the bottom housing 100. While the preferred embodiment shows four inner rib walls 110 – 113 and four outer rib walls 114-117 it is contemplated that a greater or lesser number of overlapping can be used. In Figures 2 and 3 the overlap 120 is labeled, and in the preferred embodiment the overlap angle is between 5 and 15 degrees, but prototypes have been made using an overlap angle 120 of 7.5 degrees. The ribs 110-117 are arc segments that extend perpendicular from the essentially planar base 102 and 103. These angles are variable based upon the height of the rib, the material, the thickness of the rib, the desired cushion and the distance between the inner and outer ribs. In general the distance between the inner and outer ribs is controlled based upon the annular rib in the top clam shell housing.

The overlapping double wall provides maximum protection from shock or impact to the exterior of the containment device by positioning the inner and outer wall in an offset and overlapping configuration as to increase the protection of the semiconductor wafers from direct transmission forces by increasing the amount of flex movement allowed by the outer wall. Increasing the flex tolerance of the outer wall increases the overall shock absorbing ability of the containment device. This design also allows for a greater percentage of “wrap” around the semiconductor wafer and therefore minimize lateral shift into the gaps between inner wall segments. Segmenting the inner wall makes it more flexible and thus able to absorb and cushion the wafers if the container is dropped or subject to impact.

As shown in Figures 1 and 3. The outer rib walls 114-117 need not be the same height as the inner rib 110-113 walls. In some cases, the lowered exterior wall allows for greater top cover deflection during impact before it touches the inner wall. The image in the figures shows the exterior rib walls 114-117 at approximately 2/3rds the height of the inner rib walls 110-113 as shown in Figure 1.

FIG. 4 shows a top view of the bi-directional locking feature in the bottom housing 100. FIG. 5 shows a perspective view of the bi-directional locking feature on the bottom housing 100. FIG 6 shows a perspective view of the bi-directional locking feature on the top housing 50. Starting with Figure 6 the circular rib 51 is shown
5 extending from the planar base of the top housing 50. A “U” shaped rib extends from the circular rib 51 to the outer edge 55 of the top housing 50 and around to join back with the circular rib 51. This “U” shaped rib can exist in a variety of shapes to provide a key to ensure that it locks into only one of four possible orientations with the bottom housing 100. This “U” shaped rib that extends to the outer edge 55 has an
10 inside face 53 and an outside face 52. Where the “U” shaped rib joins with the outer edge 55 there is an outside protection and support rib 54.

A pair of securing ribs consisting of an outer locking rib 131 and an inner locking rib 132 on the bottom housing 100 are configured to engage onto the opposing sides of the inside face 53 and an outside face 52 of the “U” shaped rib
15 when the “U” shaped rib is engaged into the locking cavity 130. Circular lock rib 133 is configured to fit within cavity 56 on the top housing 50 along with the inner lock rib 132. When the rib defined by items 52/53 is engaged into the locking cavity 130 these features improve orienting, the top housing 50 on the bottom housing 100 that decreases the amount of top cover 50 rotation and movement with respect to the
20 bottom member 100. This feature creates a double locking location that securely locates and locks the top cover 50 in place during top cover assembly. The bi-directional rotation locking further increases the rigidity of the containment device when the members are assembled. The “U” shaped and is shown in an approximate orthogonal relationship to three sides of the bottom housing 100. While only one
25 location of the bi-directional lock is shown and described in detail, the feature exists on all four sides of the top and bottom housings.

FIG. 7 shows an inside plan view of the top housing showing the orientation features and FIG. 8 shows inside plan view of the bottom housing showing the orientation features. FIG. 9 shows a detail perspective view of the orientation key in the top housing. FIG. 10 shows a detail perspective view without the orientation key
5 in the top housing. FIG. 11 shows a detail perspective view of the clearance for the orientation key in the bottom housing. FIG. 12 shows a detail perspective view of the interference for the orientation key in the bottom housing. For perspective, the area's 90, 91, 92 and 93 are shown enlarged and in perspective in figures 9, 10, 11 and 12 to show the orientation tab 60 and how it allows or blocks seating of the top and bottom
10 housings 50 and 100.

In Figure 9 the orientation rib 60 is shown extending essentially normal from the circular rib 51 at a particular distance 62 from the corner of the "U" shaped rib 54 and 57. In figure 10 the orientation rib is not present in area 61 in the corner of the "U" shaped rib 54 and 58. Now refer to Figures 11 and 12 to see where the
15 orientation rib 60 would be blocked or bypassed by the details. In Figure 11 the dimension 106 between the corner radius of curved lock rib 133 and the inner lock rib 132 is shorter than the distance 107 between the curved lock rib 134 and the inner lock rib 132 in figure 12. Upon placement of the top housing onto the bottom in an out of proper orientation arrangement the longer circular block rib 134 would interfere
20 with the orientation rib 60. In the correct orientation the shorter circular lock rib 133 would clear the orientation tab 60.

From figure 7, a total of four orientation tabs are shown to allow the housings to sit flat on the orientation tabs when the housings are not properly aligned. The orientation tabs 60 prevent improper assembly of said top housing and said bottom
25 housing members from being installed 90 degrees out of alignment.

FIG. 13 shows a top perspective view of the bottom housing. FIG. 14 shows a detailed perspective view of the hold down latch. FIG. 15 shows a perspective cross section of the hold down latch. In views 13 and 15 some parts of the circular ribs 110, 111, 114 and 115 are visible to help to provide a visual orientation for the pocket 80 and latch features. The bottom housing 100 has an undercut hold down recessed pocket 80 with a latch surface tab 81 for a retention mechanism to hold the housing in automated assembly. The latch surface is formed in a molding process with the molding of said bottom housing 100. The latch surface 81 is located at a height that is equal to or lower than the planar bottom surface 103 of said bottom housing 100. The latch surface 81 further has an angled or curved entry surface 82. The pocket further has at least two essentially vertical side walls 83 to self center said bottom housing on said retention mechanism.

The height of the latch is equal to or lower than the inner wall structure to allow equipment to interface with the bottom member of the container without interference with the equipment and recess pocket 80 and the latch surface 81. This recessed feature also protects the mating surface from damage when the top cover is disassembled from the bottom member. In Figures 13 and 15 housing latches 70, 71 and 72 are shown. These latches secured the top and bottom housings together.

In figures 13 and 15 a plurality of bearing ribs 85 are shown. These ribs are configured to distribute the load from a bottom housing stacked on top of the top housing. Looking briefly at figure 18, it can be seen that the annular lip 87 of the bottom housing 100 is placed at a different dimension from the annular lip 86 of the top housing 50. This allows the housings to stack or nest. When stacking multiple wafer containers together the weight of the container when filled with wafers is significant. Some wafer containers are enclosed in a protective plastic bag, and when the stacked bearing surface is small this creates a high bearing load which damages or punctures the protective bag. Calculation and testing has identified that multiple bearing surfaces 85 of greater than 2.25mm^2 each with more than 4 bearing ribs 85 per quadrant will adequately protect the containers from damage and will also prevent the protective plastic bags from being punctured or damaged.

FIG. 16 shows a perspective view of the top and bottom latch tab engaged. FIG. 17 shows a side view of the bottom latch tab. FIG 18 shows a sectional view of the latch engaged between the top and bottom housings. FIG 19 shows a detailed view of the engaged between the top and bottom housings. The bottom housing 100 has at least one latch that engages in a corresponding notch 75 located on the top housing 50.

The top surface 74 of said latch 70 is located at a height 76 that is below the top surface of said at least one rib 141. The height 76 of the latch 70 is equal to or lower than the inner wall 141 structure. This allows equipment to interface with the bottom member of the container without interference with the equipment and latch height. This further reduces the possibility of damage to the latch 70 if the bottom housing 100 is dragged on a surface. In the preferred embodiment there are four latches 70 and four corresponding notches 75 located in each corner region of said top housing 50 or said bottom 100 housing, but as few as one or two are contemplate as well as four or more latches. Figure 19 shows that the notch 70 has a curve entry ramp 77 and a recess 78 that elevates the latch 70 above said entry ramp 77 and lowers said latch 70 into the recess 78 to retain the latch 70 in the recess 78. When the latch(s) are secured the top of the inner rib wall 111 is tightly engaged and captured on the corresponding surface 84 of the top housing 50. The notch 75 is located in a latch pocket 140 that protects the latch 70 during handling and impact.

FIG. 20 shows a perspective view of the top and bottom housings in an open exploded view for reference of the internal components. This view provides a view into the open cavity of the top housing 50 and the bottom housing 100 without obstruction of the semiconductor wafers.

Thus, specific embodiments of a semiconductor wafer container have been disclosed. It should be apparent, however, to those skilled in the art that many more modifications besides those described are possible without departing from the inventive concepts herein. The inventive subject matter, therefore, is not to be restricted except in the spirit of the appended claims.

Claims

1. A wafer container comprising:
 - a top housing and a bottom housing arranged to nest together to form a clam shell
 - housing with an inner cavity for storage for at least one semiconductor wafer;
 - said top housing having an essentially planar rectangular base with at least one rib that extends perpendicular from said base in an essentially circular orientation;
 - said bottom housing having an essentially planar rectangular base with a plurality of inner and outer arc sector ribs that extend perpendicular from said base wherein said inner and outer arc sectors ribs are arranged concentric with said at least one rib that extends perpendicular from said base of said top housing, and
 - said inner and outer arc sector ribs are formed such that the arc sector of at least one inner rib overlaps the arc sector of at least two outer ribs wherein said overlap of said at least one inner arc sector rib and said at least two outer arc sector ribs is an overlap of between 5 and 15 degrees when measured from a concentric origin of said arc sector ribs.
2. The wafer container according to claim 1 wherein said at least one inner rib and said at least one outer rib extend from said essentially planar rectangular base the same height.
3. The wafer container according to claim 1 wherein said at least one inner arc sector rib and said at least one outer arc sector rib extend from said essentially planar rectangular base different heights.
4. The wafer container according to claim 1 that further includes:
 - at least one additional rib that extends from said bottom of said essentially rectangular base that is orthogonal to at least one side of said bottom;
 - a bi-directional locking feature having at least one set of locating ribs that extend from said essentially planar base of said bottom housing for locating and capturing opposing sides of said at least one additional rib that extends from said bottom of said essentially rectangular base that is orthogonal to at least one side of said bottom, wherein said locking feature being for creating a bi-directional lock of said top and said bottom housing to minimize rotation there between.
5. The wafer container according to claim 4 wherein said at least one additional rib

that extends from said bottom of said essentially rectangular base that is orthogonal to at least one side of said bottom is U-shaped and is orthogonal to three sides of said bottom.

5 6. The wafer container according to claim 5 wherein there are four sets of said U-shaped rib.

7. The wafer container according to claim 5 wherein said bi-directional locking feature captures at least two sides of said U-shaped rib.

10 8. The wafer container according to claim 1 wherein said at least one rib on said top housing has an orientation tab that extends normal to said rib on an outward direction of said circular orientation, and

15 said at least one rib on said bottom housing is configured to only clear said orientation tab when said top housing and said bottom housing are placed in only one orientation.

9. The wafer container according to claim 8 wherein there are at least four orientation tabs.

20 10. The wafer container according to claim 8 wherein said orientation tabs prevent improper assembly of said top housing and said bottom housing members from being installed 90 degrees out of alignment.

25 11. The wafer container according to claim 8 wherein said orientation tab is protectively located adjacent to a U-shaped rib that extends from said essentially circular oriented rib.

30 12. The wafer container according to claim 1 wherein said bottom housing has an undercut recessed pocket with a latch surface for a retention mechanism wherein said latch surface exists below said wafer supporting wall;

 said latch surface being formed in a molding process with the molding of said bottom housing.

35 13. The wafer container according to claim 12 wherein said latch surface is located at a height that is equal to or lower than the planar bottom surface of said bottom housing.

14. The wafer container according to claim 12 wherein said latch surface further has an angled or curved entry surface.

5 15. The wafer container according to claim 12 wherein said pocket further has at least two essentially vertical side walls to self-center said bottom housing on said retention mechanism.

10 16. The wafer container according to claim 1 wherein said bottom housing has at least one latch for engaging in a corresponding notch located on said top housing, wherein said at least one latch surface exists below said wafer supporting wall, and
said a top surface of said latch is located at a height that is below a top surface of said at least one rib.

15 17. The wafer container according to claim 16 wherein said at least one latch includes at least four latches and four corresponding notches located in each corner region of said top housing or said bottom housing.

20 18. The wafer container according to claim 16 wherein said notch has a curve entry ramp and recess arranged to elevate said latch above said entry ramp and to lower said latch into said recess to retain said latch in said recess when normal forces are applied to said top housing and said bottom housing.

25 19. The wafer container according to claim 16 wherein said notch is located in a pocket that protects said latch during handling and impact.

20. The wafer container according to claim 1 wherein:
said bottom housing having an outer annular lip;
said top housing having an outer annular lip that is configured to nest and fit within
30 said outer annular lip of said bottom housing, and
said bottom housing further having a plurality of bearing ribs that extend from said essentially rectangular base to support said annular lip on said top housing.

35 21. The wafer container according to claim 20 wherein said plurality of bearing ribs exist in at least four per quadrant on said bottom housing.

22. The wafer container according to claim 20 wherein said plurality of bearing ribs create a bearing surface of at least 2.25 mm².
- 5 23. The wafer container according to claim 20 wherein said plurality of bearing ribs reduce damage to at least one of stacking pads and the top rim of the housings.