sit in a conforming region in the bottom of the cassette without being secured therein other than by gravity. The bottom cushion has rails extending in an axial direction from which the arcuate wafer cushion segments are suspended. The bottom cushion rails may have pads extending laterally and that contact the upward seating surface of the base portion. The feet of the cassette portion may seat on these pads such that the pads are sandwiched between base portion and cassette portion.

An embodiment of the invention provides a wafer shipper in which the upper cushion is secured to the inside of the top cover and the upper cushion has prongs that extend radially inward at least 5 mm from the peripheral edge of a 100 mm wafer seated in the cassette.

An embodiment of the invention provides a wafer shipper in which the maximum radial distance that the guides extend inwardly from edges of wafers held therein is within 20% of the maximum radial distance from the edges of the wafers that the teeth extend inwardly.

The result of the side wall ribs together with the top and bottom cover cushion assemblies is to support each wafer in the container on a larger portion of the circumference of the wafer thereby reducing the stress points created where the previous wafer cushions contacted the wafer edge. The wafer is suspended away from the slots in the sidewalls when enclosed in the container portion. However, the gap may be .005 - .015 inches and may permit contact with the sidewalls at the grooves when under an impact condition.

An advantage of embodiments of the invention is that the cassette, the top cover, the bottom cover, the two wafer cushions may be formed of the same polymer material, such as polypropylene. This makes identifying contamination issues associated with wafers carried in the container much easier as there is only one material to investigate as the possible contaminant source with respect to the shipper.

An advantage of an embodiment of the present invention is a wafer container for carrying a plurality of axially aligned thin semiconductor wafers. The container has a cassette portion with side wafer supports that cooperate with the cushion assemblies in the top and bottom cover to support thin wafers for short term storage and transportation.

Another advantage of an embodiment is the cushion design includes a spring mechanism that provides compressive force to the wafers to prevent rotation during transit/shipping

Another advantage of an embodiment is the cushion design includes an alignment feature at the edges of the upper cushion to prevent wafer cross-slotting.

Another advantage of embodiments of the invention is that the lower cushion is seated in the bottom by simply placing the cushion therein in a conforming recess. Additionally in embodiments, the cushion has a pair of horizontal rails extending in an axial direction with respect to the wafers, with a plurality of wafer cushion segments extending therebetween. The rails may have pads extend therefrom that are sandwiched

Referring to Figures 3-10, details of the bottom base portion 24 of the container portion 22 and the wafer cushion are illustrated. The container has an axial direction consistent with the axis a of wafers in place in the cassette that is placed in the container. In this embodiment, the wafer cushion is configured as a panel, that it, there is not separation between individual wafer engagement portions or segments 56. The cushion has a pair of rails 58 that provide structural support for the arcuate wafer engagement portions 56. Extending from the lower edge portion 58 of the rails are tabs or pads 62 with leg portions 63. The pads have a bottom surface 64 that contacts the seating surface 66 of the bottom floor 68 of the base portion 24. The bottom floor of the base portion has a cushion receiving area 70, configured as an axially extending gutter 71, which conforms to the cushion and particularly the rails of the cushion. That is, recessed areas 72 allow the cushion to be essentially dropped into place and it properly seats. The rails also have notches 74 that further cooperate with locating ribs 76 recessed area of the base portion. The rails further facilitate the very easy placement of the cushion. Notably there is no further operation in installing the bottom cushion other that dropping it in place.

Also, the bottom portion has a four walls 82 with two end walls 84 and two side walls defining the enclosure. Two angled or inclined wall portions 86 with inclined surfaces 88 that further aid in guiding the bottom cushion into proper seating position.

The base portion also receives and is conformingly shaped for the cassette 30. The cassette has a pair of sidewalls 92 connected with end walls 93 and 94. The sidewalls have vertical upper portions 95 and converging lower portions 96 and ribs or teeth 98 that define slots 100. Extending downwardly from the bottom edge 102 of the converging wall portions are a pair of feet 106 with edge portion 108 and edge surfaces 110. The feet have locating notches 112. The cassette sits on the feet when the open top is oriented upwardly. The cassette has an open top 113 and an open bottom 114. Often for robotically loading and unloading such cassettes, the cassette will be rotated forward 90 degrees and rest on the conventional H-bar 116 such that wafers may be loaded and unloaded horizontally.

The recessed area 70 and the inclined surfaces 88 further provide guidance for the feet of the cassette 30 when lowered into the base portion. The cassette is placed in the base portion after the lower cushion 34 is placed therein. The feet are guided into the cassette receiving region ~~116~~ which is in the gutter 71 laterally outside of the rails of the cushion. The lower edges, in certain embodiments, rather that seat on the surface of the

Claims

1. A wafer shipper comprising a cassette and a cassette container and configured for holding thin wafers,

the cassette comprising a pair of sidewalls defining slots for holding wafers, a pair of endwalls extending between the sidewalls, one of the endwalls configured as an H-bar machine interface, and pair of elongate feet extending downwardly from the respective sidewalls;

the cassette container comprising a bottom base portion for receiving the cassette therein, and a top cover attachable to bottom base portion, each of the top cover and base portion having four walls and a common wall spanning between the four walls, each of the top cover and base portion having a juncture for closing the top cover to the base portion, the cassette container further comprising an upper cushion attachable to the top cover and a lower cushion that seats in a receiving region in the bottom base portion;

~~wherein the upper cushion is secured to the inside of the top cover and the upper cushion has a pair of rails that attach to the top cover, and that support a plurality of wafer engaging segments, the wafer engaging segments connecting to the pair of rails by way of a respective pair of U-shaped springs formed of the same material as the wafer engaging segments~~

wherein the upper cushion is secured to the inside of the top cover and the upper cushion has teeth defining V-shaped grooves for receiving the periphery of the wafers, the V-shaped grooves defining wafer slots, the upper cushion having a plurality of prongs each positioned intermediate the slots defined by the V-shaped grooves whereby the prongs extend inwardly beyond the teeth intermediate the wafers.

2. The wafer shipper of claim 1 wherein the base portion has a locator rib extending from a floor of the base portion, and wherein the cassette has a foot with lower edge portion, the lower edge portion having a notch positioned to seat on the locator rib when the cassette is placed in the bottom base portion, and wherein the lower cushion has a pair of rails with a wafer engagement portions extending therebetween, the rails having a lower edge portion and at least one of said lower edge portions having a centrally positioned notch positioned to also seat on the locating rib.

3. The wafer shipper of claim 1 or 2 wherein the lower wafer cushion comprises a pair of rails supporting a plurality wafer engagement portions, and wherein the lower cushion further comprises a plurality of pads extending laterally out from the pair of rails, and wherein the wafer cushion seats on a floor of the base portion by way of the plurality of pads.

4. The wafer shipper of claim 3 wherein each of the pads has a top surface and when the cassette is positioned in the base portion the feet of the cassette seat on top of the pads whereby the pads are sandwiched between the base portion floor and the cassette.

5. The wafer shipper of claim 1 or 3 wherein the upper cushion is secured to the inside of the top cover and the upper cushion has prongs that extend radially inward at least 5 mm from the peripheral edge of a 100 mm wafer seated in the cassette.

~~6. The wafer shipper of claim 1 wherein the lower cushion is secured to the inside of the bottom cover and the lower cushion has a pair of rails that support a plurality of wafer engaging segments, the wafer engaging segments connecting to the pair of rails by way of a respective pair of U-shaped springs formed of the same material as the wafer engaging segments.~~

~~7. The wafer shipper of claim 1 or 6 wherein the upper cushion is secured to the inside of the top cover and the upper cushion has V-shaped grooves for receiving the periphery of the wafers, the V-shaped grooves defining wafer slots, the upper cushion having a plurality of prongs each positioned intermediate the slots defined by the V-shaped grooves.~~

~~8. The wafer shipper of claim 1 or 6 wherein the upper cushion is secured to the inside of the top cover and the upper cushion has a plurality of wafer engaging segments, each having a V-shaped groove with a maximum depth, the V-shaped grooves for receiving the periphery of the wafers, the upper cushion having a plurality of prongs each positioned intermediate the slots defined by the V-shaped grooves and positioned to be the first part of the wafer cushion to confront the wafers when the top cover is installed on a base portion with a cassette loaded with wafers therein.~~

~~9~~6. The wafer shipper of claim ~~8~~1 wherein each of the prongs extends radially inward from the periphery of the wafer when the top cover is fully seated on the bottom base portion, a distance at least twice the maximum depth of the V-shaped grooves.

~~10~~7. The wafer shipper of claim 1 ~~or 6~~ wherein the lower cushion seats in the bottom base portion and is secured therein only by gravity herein when the cassette is not seated.

~~11. A wafer shipper comprising a cassette and a cassette container,~~

~~the cassette comprising a pair of sidewalls defining slots for holding wafers, a pair of endwalls extending between the sidewalls, one of the endwalls configured as an H-bar machine interface, and pair of elongate feet extending downwardly from the respective sidewalls;the cassette container comprising a bottom base portion for receiving the cassette therein, and a top cover attachable to bottom base portion, each of the top cover and base portion having four walls and a common wall spanning between the four walls, each of the top cover and base portion having a juncture for closing the top cover to the base portion, the cassette container further comprising an upper cushion attachable to the top cover and a lower cushion received in the bottom base portion, the upper cushion being secured to the inside of the top cover and the upper cushion has a pair of rails that attach to the top cover and that support a plurality of wafer engaging segments, the wafer engaging segments connecting to the pair of rails by way of a respective pair of U-shaped springs formed of the same material as the wafer engaging segments.~~

~~12. A wafer shipper comprising a cassette and a cassette container,~~

~~the cassette comprising a pair of sidewalls defining slots for holding wafers, a pair of endwalls extending between the sidewalls, one of the endwalls configured as an H-bar machine interface, and pair of elongate feet extending downwardly from the respective sidewalls;~~

~~the cassette container comprising a bottom base portion for receiving the cassette therein, and a top cover attachable to bottom base portion, each of the top cover and base portion having four walls and a common wall spanning between the four walls, each of the top cover and base portion having a juncture for closing the top cover to the base portion, the cassette container further comprising an upper cushion attachable to the top cover and a lower cushion received in the bottom base portion, the upper cushion being secured to the inside of the top cover and the~~

~~upper cushion has a pair of rails that attach to the top cover and that support a plurality of wafer engaging segments, the wafer engaging segments connecting to the pair of rails by way of a respective pair of U-shaped springs formed of the same material as the wafer engaging segments.~~

~~13~~8. A wafer shipper comprising a cassette and a cassette container,

the cassette comprising a pair of sidewalls defining slots for holding wafers, a pair of endwalls extending between the sidewalls, one of the endwalls configured as an H-bar machine interface, and pair of elongate feet extending downwardly from the respective sidewalls;

the cassette container comprising a bottom base portion for receiving the cassette therein, and a top cover attachable to bottom base portion, each of the top cover and base portion having four walls and a common wall spanning between the four walls, each of the top cover and base portion having a juncture for closing the top cover to the base portion, the cassette container further comprising an upper cushion attachable to the top cover and a lower cushion received in the bottom base portion, the upper cushion being secured to the inside of the top cover and the upper cushion has a pair of rails that attach to the top cover and that support a plurality of wafer engaging segments, the wafer engaging segments each having a V-shaped groove, the upper cushion further comprising a plurality of tapered guides, each with a tip, extending downwardly from the rails, the tapered guides each positioned such that tips of the guides move past the periphery of the wafers before the wafer peripheries enter the V-shaped grooves.

~~14~~9. A wafer shipper comprising a cassette and a cassette container,

the cassette comprising a pair of sidewalls defining slots for holding wafers, a pair of endwalls extending between the sidewalls, one of the endwalls configured as an H-bar machine interface, and pair of elongate feet extending downwardly from the respective sidewalls;

the cassette container comprising a bottom base portion for receiving the cassette therein, and a top cover attachable to bottom base portion, each of the top cover and base portion having four walls and a common wall spanning between the four walls, each of the top cover and base portion having a juncture for closing the top cover to the base portion, the cassette container further comprising an upper cushion attachable to the top cover and a lower cushion received in the bottom base portion, and wherein the lower wafer cushion comprises a pair of rails supporting a plurality wafer engagement portions, and wherein the lower cushion further

comprises a plurality of pads extending laterally out from the pair of rails, and wherein the wafer cushion seats on a floor of the base portion by way of the plurality of pads and each of the pads has a top surface and when the cassette is positioned in the base portion, the feet of the cassette seat on top of the pads whereby the pads are sandwiched between the base portion floor and the cassette.

~~15~~10. A method of protecting thin wafers in an H-bar cassette during shipment, the H-bar wafer cassette having a plurality of slots with each slot having a rigid edge portion at the bottom of the slot, the method comprising:

raising the wafers out of contact with the cassette by suspending the wafers between a row of end suspended upper arcuate wafer engagement portions engaging an arcuate edge portion centered about top dead center of the wafers and a row of end suspended lower arcuate wafer engagement portions engaging an arcuate edge portion centered about the bottom top dead center of the wafers;

spacing the wafers from the cassette such that there is a predetermined radial gap between each of the wafers and each respective rigid edge portion and positioning the lower cushion such that there is a predetermined circumferential gap between the end of each lower arcuate wafer engagement portion and the rigid edge portion; and providing one or both of the following steps:

providing further a pair of rows of rigid upper arcuate support portions, each arcuate support portion spaced from an end of the end suspended upper arcuate wafer engagement portions, the positioning of the pair of rows of rigid upper arcuate support portions in substantial vertical alignment with the rigid edge portions, and

providing a pair of rows of prongs extending from the top cover positioned for extending intermediate adjacent wafers, each row of prongs in vertical alignment with one of the respective rows of rigid edge portions.

~~16~~11. The method of claim ~~15~~10 further comprising providing a gap between the wafers and the rows of rigid upper arcuate support portions such that the wafers during shipment do not contact the rigid upper arcuate support portions and do not contact the rigid edge portions except in a shock condition.

~~17~~12. A method of protecting thin wafers in an H-bar cassette during shipment, the H-bar wafer cassette having a plurality of slots with each slot having a rigid edge portion at the bottom of the slot, the method comprising:

raising the wafers out of contact with the cassette by suspending the wafers between a row of end suspended upper arcuate wafer engagement portions engaging an arcuate edge portion centered about top dead center of the wafers and a row of end suspended lower arcuate wafer engagement portions engaging an arcuate edge portion centered about the bottom top dead center of the wafers;

spacing the wafers from the cassette such that there is a predetermined radial gap between each of the wafers and each respective rigid edge portion and positioning the lower cushion such that there is a predetermined circumferential gap between the end of each lower arcuate wafer engagement portion and the rigid edge portion; ~~and~~

providing further a pair of rows of rigid upper arcuate support portions, each arcuate support portion spaced from an end of the end suspended upper arcuate wafer engagement portions, the positioning of the pair of rows of rigid upper arcuate support portions in substantial vertical alignment with the rigid edge portions, and spacing each rigid upper arcuate support portion such that it has a radial gap corresponding to the predetermined radial gap between each of the wafers and each respective rigid edge portion; and

providing a pair of rows of prongs positioned for extending intermediate adjacent wafers, each row of prongs in vertical alignment with one of the respective rows of rigid edge portions, each prong extending inwardly a maximum radial distance substantially equivalent to the maximum radial distance that the teeth extend inwardly.

~~18. The method of claim 17 further comprising providing a pair of rows of prongs positioned for extending intermediate adjacent wafers, each row of prongs in vertical alignment with one of the respective rows of rigid edge portions, each prong extending inwardly a maximum radial distance substantially equivalent to the maximum radial distance that the teeth extend inwardly.~~

~~19~~13. A method of protecting thin wafers during shipment comprising:

suspending the wafers between a row of upper arcuate wafer engagement portions and lower arcuate wafer engaging portions each with V-shaped grooves for engaging the wafers, the upper arcuate wafer engagement portions and lower arcuate wafer engagement portions each being supported spanning arcs at top dead center of the respective wafers and rows of lower arcuate wafer engagement portions spanning arcs at bottom dead center of the respective wafers, the upper and lower arcuate wafer engagement portions each having a pair of ends;

providing further more rigid arcuate support at pairs of rigid supports spaced from each ends of the upper arcuate wafer engagement portions and spaced from each end at the lower arcuate wafer engagement portions each end of the arcuate wafer cushions, the more rigid supports not engaged with the wafers during shipment except when in a shock condition;

providing further prongs extending downwardly intermediate the wafers, the prongs not engaging the wafers except in a shock condition.

~~20~~14. Any of the above claims wherein each of the components are formed of polypropylene.

~~21~~15. A wafer cushion for placement at the open top of an H-bar wafer cassette, the cushion having a plurality of separate and end supported arcuate wafer engaging segments each having a V-shaped groove, a U-shaped spring extending from each end of each wafer engaging segment, each U-shaped spring connecting to a rail portion, the rail portion providing a rigid arcuate wafer engagement surface that is radially spaced outward from the respective arcuate wafer engaging segments, each rail further having a plurality of prongs extending radially inward for placement inbetween wafers secured by the wafer engaging segments.

~~22~~16. A wafer shipper having a cassette with opposing sidewalls, the sidewalls connected by opposing end walls, each sidewall having a vertical upper portion and a converging lower portion, interior surfaces of the sidewalls defining a plurality of teeth with slots therebetween for holding axially aligned wafers, a cushion for placement at the open top of the H-bar wafer cassette, the cushion having a plurality of arcuate wafer engaging segments each having a V-shaped groove, each V-shaped groove having a height measured in a radial direction,

the cushion further having a plurality of guides positioned proximate the ends of the wafer engaging segments, the guides extending radially inward for placement in vertical alignment with the teeth of the cassette.

~~23~~17. The wafer shipper of claim ~~22~~16 wherein the guides extend inwardly a maximum radial distance from edges of wafers held therein and wherein the teeth extend inwardly a maximum radial distance from the edges of the wafers held therein that is substantially the same as the maximum radial distance that the guides extend inwardly from the edges of the wafers.

~~24~~18. The wafer shipper of claim ~~23~~17, wherein the maximum radial distance that the guides extend inwardly from edges of wafers held therein is within 20% of the maximum radial distance from the edges of the wafers that the teeth extend inwardly.

~~25~~19. The wafer shipper of any one of claims ~~22~~16, ~~23~~17, and ~~24~~18, wherein each of the teeth have a most lower portion and the guides are in vertical alignment with the most lower portion of the teeth.