limited success, and have not fully addressed the problem of wafer damage when containers are transported.

What is needed in the industry is a wafer container that provides greater physical shock resistance and better wafer support under typical shipping conditions.

SUMMARY OF THE INVENTION

Embodiments of the invention address the need of the industry for a wafer container that provides greater physical shock resistance and better wafer support under typical shipping conditions, particularly as those problems are experienced with containers for 450 mm diameter and larger wafers.

In an embodiment, removable shipping cushions are provided on either side of the typical primary wafer cushions on the inside surface of the front door of the wafer container. These shipping cushions provide additional, spaced-apart support for the front edges of the wafers in the containers. These shipping cushions improve the physical shock resistance performance of wafer containers including the disclosed removable shipping cushions up to double or more of that of prior art wafer containers. This allows for reduced cushioning requirements within the secondary packaging and full functionality with automation as defined in SEMI Standard E159.

According to a first aspect of the present invention, there is provided a cushioned wafer container system for use within a fabrication facility and having removable wafer cushions for using the wafer container system for transporting large-diameter wafers between facilities, the system comprising: a wafer container enclosure configured to contain a plurality of semiconductor wafers, each wafer including a wafer periphery defining a first, second, third, and fourth quadrant, the wafer container defining a front opening and comprising a rear wall, and a plurality of wafer supports defining a plurality of slots for receiving edge portions of a plurality of wafers, the wafer supports supporting a first portion of a first quadrant periphery of the wafer and a first portion of a fourth quadrant periphery of the wafer; a front door configured to attach to the wafer enclosure at the front opening and defining a front side and a rear side, the rear side presenting itself to an interior of the wafer enclosure; a primary wafer cushion coupled to a rear side of the front door at a central portion of the front door for both use within the fabrication facility and for transporting wafers between facilities, the primary wafer cushion defining a plurality of wafer grooves configured to receive and support a second portion of the first

quadrant periphery of the wafer and a second portion of the fourth quadrant periphery of the wafer, each of the grooves of the primary wafer cushion aligned with a slot of the wafer supports; a first removable wafer cushion for use only in transporting wafers between facilities, the first removable wafer cushion separate from the primary wafer cushion and attachable to the rear side of the front door adjacent a first side of the primary wafer cushion, the first removable wafer cushion defining a plurality of wafer-receiving grooves in alignment with the grooves of the primary wafer cushions and the wafer support slots, the first removable wafer cushion configured to support a third portion of the first quadrant periphery of the wafer; and a second removable wafer cushion for use only in transporting wafers between facilities, the second removable wafer cushion separate from the primary wafer cushion and attachable to the rear side of the front door adjacent a second side of the primary wafer cushion, the second removable wafer cushion defining a plurality of wafer-receiving grooves in alignment with the grooves of the primary wafer cushions and the wafer support slots, the second removable wafer cushion configured to support a third portion of the fourth quadrant periphery of the wafer.

~~According to a second aspect of the present invention, there is provided~~ Disclosed herein is a cushioned wafer container system for use within a fabrication facility and having a removable wafer cushion for using the wafer container system for transporting large-diameter wafers between facilities, the removable wafer cushion for attaching to a rear side of a door of a large-diameter wafer container and supporting wafers contained within the wafer container only during shipment, the removable wafer cushion comprising: a first body portion defining a plurality of grooves configured to receive edge portions of the wafers and a plurality of wafer engagement portions formed within the grooves and configured to engage an edge of one of the plurality of wafers when the wafer enclosure is oriented in a vertical shipping position; a first plurality of attachment tabs distributed along a length of the first body portion and extending outwardly and away from the body portion, the attachment tabs defining distal ends configured to fit into apertures of the rear side of the door.

~~According to a third aspect of the present invention, there is provided~~ Disclosed herein is a wafer cushion kit, comprising: a wafer container enclosure for use within a fabrication facility and for use in transporting large-diameter wafers between facilities, the wafer container configured to contain a plurality of semiconductor wafers, the wafer container defining a front opening and comprising a rear wall, and a plurality of wafer

supports defining a plurality of slots for receiving edge portions of a plurality of wafers; a front door configured to attach to the wafer enclosure at the front opening and defining a front side and a rear side, the rear side presenting itself to an interior of the wafer enclosure; a first wafer cushion removably attachable to a rear side of the front door for use when the wafer container is in the fabrication facility, the first wafer cushion defining a plurality of wafer grooves for receiving edge portions of the plurality of wafers, each of the grooves of the primary wafer cushion aligned with a slot of the wafer supports, the first wafer cushion configured to engage and support a plurality of wafers in a horizontal position; and a second wafer cushion removably attachable to a rear side of the front door for use in transporting large-diameter wafers between facilities, the second wafer cushion defining a plurality of wafer grooves for receiving edge portions of the plurality of wafers, each of the grooves of the primary wafer cushion aligned with a slot of the wafer supports, the second wafer cushion configured to engage and support the plurality of wafers in a vertical position; wherein the front door is configured to receive either the first wafer cushion or the second wafer cushion.

According to a ~~fourth~~ second aspect of the present invention, there is provided a method for converting a large-diameter, horizontal wafer container used in fabrication facilities into a wafer shipper for shipping wafers between facilities, the method comprising: removing a door of the wafer container from an enclosure of the wafer container; attaching a first removable wafer cushion to a first portion of the door of the wafer container adjacent a first side of a primary wafer cushion attached to the door, the primary wafer cushion located centrally on the door and configured to support a wafer during a fabrication process; and attaching a second removable wafer cushion to a second portion of the door of the wafer container adjacent a second side of the primary wafer cushion attached to the door.

~~According to a fifth aspect of the present invention, there is provided~~ Disclosed herein is a method for converting a large-diameter, horizontal wafer container for use within a fabrication facility into a wafer shipper used for shipping wafers between facilities, the method comprising: removing a door of the wafer container from an enclosure of the wafer container; removing a primary wafer cushion for use within the fabrication facility from the door of the wafer container; and attaching a removable wafer cushion used for shipping wafers between facilities to the door, thereby replacing the primary wafer cushion, the removable wafer cushion configured to engage a greater

circumferential portion of each of a plurality of wafers to be contained in the wafer container.

~~According to a sixth aspect of the present invention, there is provided~~ Disclosed herein is a method for converting a large-diameter, horizontal wafer container used in fabrication facilities into a wafer shipper for shipping wafers between facilities, the wafer container having a container portion with opposing wafer supports each with a column of wafer shelves, and a door with a central wafer cushion, the forward left and forward right edges of the wafers being forward of the forwardmost ends of the wafer support shelves on the left side and the right side of the wafer container portion, the method comprising inserting a removable left wafer support used only for transporting wafers between facilities to the inside surface of the door laterally outward from the central wafer cushion, the wafer support generally having a triangular footprint, and inserting a removable right wafer support used only for transporting wafers between facilities to the inside of the door laterally outward from the central wafer cushion, the removable right wafer support having a triangular foot print.

According to a ~~seventh~~ third aspect of the present invention, there is provided a method of shipping 450 mm wafer in a 450 multi application container usable within fabrication facilities and usable for shipping wafers between facilities, the multi application container having a door with a central wafer cushion thereon the central wafer cushion usable within fabrication facilities and usable for shipping wafers between facilities, the method comprising installing on the inside front surface of the door a pair of supplemental wafer cushions that are each separate from the central wafer cushion for use for shipping the wafers between facilities, one on each lateral side of the central cushions, the two supplemental cushions supporting wafers in the container on the edges intermediate wafer support shelves and the central wafer cushion.

According to ~~an eighth~~ a fourth aspect of the present invention, there is provided a method of shipping 450 mm wafers between facilities in a 450 container for use within the fabrication facility, the container having a door with a central wafer cushion thereon for when the container is used in the fabrication facility and also for when the container is used for shipping wafer between facilities, the method comprising installing on the inside front surface of the door a pair of supplemental wafer cushions that are each separate from the central wafer cushion, one on each lateral side of the central cushions, the two supplemental cushions supporting wafers in the container on the edges angularly spaced

from a centerline perpendicular to the door in a region 30 to 45 degrees from said centerline.

~~According to a ninth aspect of the present invention, there is provided~~ Disclosed herein is a shipping wafer cushion used for shipping wafers and for placement on the inside surface of a door adjacent to existing cushions that are used in a fabrication facility and for shipping wafers, the shipping wafer cushion comprising an arcuate portion with a plurality of grooves for engaging the wafers, a spring portion extending from the arcuate portion with a plurality of taps thereon opposite from the spring portion, the tabs for connecting to slots in the door and for putting the spring portion and arcuate portion under compressive tension to secure the spring in place.

~~According to a tenth aspect of the present invention, there is provided~~ Disclosed herein is a method of shipping 450 mm wafer in a 450 multi application container usable within fabrication facilities and usable for shipping wafers between facilities, the method comprising: providing support to the forward left and forward right edges of wafers in a wafer container, the wafer container having a container portion with opposing wafer supports each with a column of wafer shelves, and a door with a central wafer cushion, the forward left and forward right edges of the wafers being forward of the forwardmost ends of the wafer support shelves on the left side and the right side of the wafer container portion, the providing support including inserting a removable left wafer support to the inside surface of the door laterally outward from the central wafer cushion, the wafer support generally having a V-shaped footprint, and inserting a removable right wafer support to the inside of the door laterally outward from the central wafer cushion, the removable right wafer support having a V-shaped foot print.

BRIEF DESCRIPTION OF THE DRAWINGS

The embodiments of the present invention may be more completely understood in consideration of the following detailed description of various embodiments in connection with the accompanying drawings, in which:

Figure 1 is an exploded front isometric view of a front-opening wafer container with removable shipping cushions according to an embodiment of the invention;

CLAIMS

1. A cushioned wafer container system for use within a fabrication facility and having removable wafer cushions for using the wafer container system for transporting large-diameter wafers between facilities, the system comprising:

a wafer container enclosure configured to contain a plurality of semiconductor wafers, each wafer including a wafer periphery defining a first, second, third, and fourth quadrant, the wafer container defining a front opening and comprising a rear wall, and a plurality of wafer supports defining a plurality of slots for receiving edge portions of a plurality of wafers, the wafer supports supporting a first portion of a first quadrant periphery of the wafer and a first portion of a fourth quadrant periphery of the wafer;

a front door configured to attach to the wafer enclosure at the front opening and defining a front side and a rear side, the rear side presenting itself to an interior of the wafer enclosure;

a primary wafer cushion coupled to a rear side of the front door at a central portion of the front door for both use within the fabrication facility and for transporting wafers between facilities, the primary wafer cushion defining a plurality of wafer grooves configured to receive and support a second portion of the first quadrant periphery of the wafer and a second portion of the fourth quadrant periphery of the wafer, each of the grooves of the primary wafer cushion aligned with a slot of the wafer supports;

a first removable wafer cushion for use only in transporting wafers between facilities, the first removable wafer cushion separate from the primary wafer cushion and attachable to the rear side of the front door adjacent a first side of the primary wafer cushion, the first removable wafer cushion defining a plurality of wafer-receiving grooves in alignment with the grooves of the primary wafer cushions and the wafer support slots, the first removable wafer cushion configured to support a third portion of the first quadrant periphery of the wafer; and

a second removable wafer cushion for use only in transporting wafers between facilities, the second removable wafer cushion separate from the primary wafer cushion and attachable to the rear side of the front door adjacent a second side of the primary wafer cushion, the second removable wafer cushion defining a plurality of wafer-receiving grooves in alignment with the grooves of the primary wafer cushions and the wafer support slots, the second removable wafer cushion configured to support a third portion of the fourth quadrant periphery of the wafer.

2. The cushioned wafer container system of claim 1, wherein the first quadrant periphery of the wafer includes a fourth, unsupported portion, the fourth unsupported portion having a peripheral length less than a peripheral length of the third portion supported by the first removable wafer cushion.

3. The cushioned wafer container system of claim 1, wherein the first removable wafer cushion includes a plurality of wafer engagement portions formed at an apex of the grooves and configured to engage an edge of one of the plurality of wafers when the wafer enclosure is oriented in a vertical shipping position.

4. The cushioned wafer container system of claim 1, wherein the first removable wafer cushion includes a plurality of attachment tabs attaching the first wafer cushion to the rear side of the door.

5. The cushioned wafer container system of claim 4, wherein the plurality of attachment tabs are received by a plurality of apertures in a vertical bulkhead of the door.

6. The cushioned wafer container system of claim 1, wherein the first removable wafer cushion presents a leading each that is parallel and adjacent to lateral margins of the primary wafer cushion.

7. The cushioned wafer container system of claim 1, further comprising a rear removable wafer cushion attached to the rear wall of the wafer enclosure and configured to engage and support portions of the wafers.

8. The cushioned wafer container system of claim 1, wherein the first removable wafer cushion is removably attached to the rear side of the door.

9. The cushioned wafer container system of claim 1, wherein the first and second removable cushions are configured to support a majority those peripheral portions of the wafer not supported by the primary cushion or the wafer supports, in the first and fourth quadrants of the wafer.

~~10. A cushioned wafer container system for use within a fabrication facility and having a removable wafer cushion for using the wafer container system for transporting large diameter wafers between facilities, the removable wafer cushion for attaching to a rear side of a door of a large diameter wafer container and supporting wafers contained within the wafer container only during shipment, the removable wafer cushion comprising:~~

~~a first body portion defining a plurality of grooves configured to receive edge portions of the wafers and a plurality of wafer engagement portions formed within the grooves and configured to engage an edge of one of the plurality of wafers when the wafer enclosure is oriented in a vertical shipping position;~~

~~a first plurality of attachment tabs distributed along a length of the first body portion and extending outwardly and away from the body portion, the attachment tabs defining distal ends configured to fit into apertures of the rear side of the door.~~

~~11. The cushioned wafer container system of claim 10, wherein each of the plurality of grooves of the removable wafer cushion define a V shape.~~

~~12. The cushioned wafer container system of claim 11, wherein each of the engagement portions are located at an apex of the V shape of each of the plurality of grooves.~~

~~13. The cushioned wafer container system of claim 10, wherein the plurality of attachment tabs comprises five attachment tabs.~~

~~14. The cushioned wafer container system of claim 10, the removable wafer cushion configured to replace a primary wafer cushion for transporting wafers between facilities, the removable wafer cushion further comprising:~~

a second body portion defining a plurality of grooves configured to receive edge portions of the wafers and a plurality of wafer engagement portions formed within the grooves and configured to engage an edge of one of the plurality of wafers when the wafer enclosure is oriented in a vertical shipping position;

a second plurality of attachment tabs distributed along a length of the second body portion and extending outwardly and away from the body portion, the attachment tabs defining distal ends configured to fit into apertures of the rear side of the door;

wherein the first body portion extends away from a vertical axis of the door in a first direction, and the second body portion extends away from the vertical axis is a second direction.

15. A wafer cushion kit, comprising:

a wafer container enclosure for use within a fabrication facility and for use in transporting large-diameter wafers between facilities, the wafer container configured to contain a plurality of semiconductor wafers, the wafer container defining a front opening and comprising a rear wall, and a plurality of wafer supports defining a plurality of slots for receiving edge portions of a plurality of wafers;

a front door configured to attach to the wafer enclosure at the front opening and defining a front side and a rear side, the rear side presenting itself to an interior of the wafer enclosure;

a first wafer cushion removably attachable to a rear side of the front door for use when the wafer container is in the fabrication facility, the first wafer cushion defining a plurality of wafer grooves for receiving edge portions of the plurality of wafers, each of the grooves of the primary wafer cushion aligned with a slot of the wafer supports, the first wafer cushion configured to engage and support a plurality of wafers in a horizontal position; and

a second wafer cushion removably attachable to a rear side of the front door for use in transporting large-diameter wafers between facilities, the second wafer cushion defining a plurality of wafer grooves for receiving edge portions of the plurality of wafers, each of the grooves of the primary wafer cushion aligned with a slot of the wafer supports, the second wafer cushion configured to engage and support the plurality of wafers in a vertical position;

wherein the front door is configured to receive either the first wafer cushion or the second wafer cushion.

~~16. The wafer cushion kit of claim 15, wherein the first wafer cushion includes a first plurality of engagement portions for engaging edge portions of the plurality of wafers, and the second wafer cushion includes a second plurality of engagement portions for engaging edge portions of the plurality of wafers.~~

~~17. The wafer cushion kit of claim 16, wherein each of the plurality of second engagement portions of the second wafer cushion engages a greater circumferential portion of each of the plurality of wafers as compared to the circumferential portion of each of the plurality of wafers as engaged by the first engagement portions of the first wafer cushion.~~

~~18. The wafer cushion kit of claim 15, wherein the second wafer cushion extends laterally, away from a center of the door, a distance that is greater than a lateral distance extended by the first wafer cushion.~~

~~19. The wafer cushion kit of claim 15, further comprising a rear wafer cushion configured to attach to the rear wall of the wafer enclosure.~~

~~20~~10. A method for converting a large-diameter, horizontal wafer container used in fabrication facilities into a wafer shipper for shipping wafers between facilities, the method comprising:

removing a door of the wafer container from an enclosure of the wafer container;

attaching a first removable wafer cushion to a first portion of the door of the wafer container adjacent a first side of a primary wafer cushion attached to the door, the primary wafer cushion located centrally on the door and configured to support a wafer during a fabrication process; and

attaching a second removable wafer cushion to a second portion of the door of the wafer container adjacent a second side of the primary wafer cushion attached to the door.

~~21~~11. The method of claim ~~20~~10, further comprising attaching a first rear removable wafer cushion at a rear wall of the enclosure.

~~22~~12. The method of claim ~~21~~11, further comprising attaching a second rear removable wafer cushion at the rear wall of the enclosure, the first rear removable wafer cushion being positioned at a left rear portion of the rear wall, and the second rear removable wafer cushion being positioned at a right rear portion of the rear wall.

~~23. A method for converting a large-diameter, horizontal wafer container for use within a fabrication facility into a wafer shipper used for shipping wafers between facilities, the method comprising:~~

~~removing a door of the wafer container from an enclosure of the wafer container;~~

~~removing a primary wafer cushion for use within the fabrication facility from the door of the wafer container; and~~

~~attaching a removable wafer cushion used for shipping wafers between facilities to the door, thereby replacing the primary wafer cushion, the removable wafer cushion configured to engage a greater circumferential portion of each of a plurality of wafers to be contained in the wafer container.~~

~~24. The method of claim 23, further comprising attaching a first rear removable wafer cushion used for shipping wafers between facilities at a rear wall of the enclosure.~~

~~25. The method of claim 24, wherein the first rear removable wafer cushion is attached at a central portion of the rear wall.~~

~~26. The method of claim 24, further comprising attaching a second rear removable wafer cushion used for shipping wafers between facilities at the rear wall of the enclosure, the first rear removable wafer cushion being positioned at a left rear portion of the rear wall, and the second rear removable wafer cushion being positioned a right rear portion of the rear wall.~~

~~27. A method for converting a large-diameter, horizontal wafer container used in fabrication facilities into a wafer shipper for shipping wafers between facilities, the wafer container having a container portion with opposing wafer supports each with a column of wafer shelves, and a door with a central wafer cushion, the forward left and forward right edges of the wafers being~~

~~forward of the forwardmost ends of the wafer support shelves on the left side and the right side of the wafer container portion, the method comprising inserting a removable left wafer support used only for transporting wafers between facilities to the inside surface of the door laterally outward from the central wafer cushion, the wafer support generally having a triangular footprint, and inserting a removable right wafer support used only for transporting wafers between facilities to the inside of the door laterally outward from the central wafer cushion, the removable right wafer support having a triangular foot print.~~

~~28~~13. A method of shipping 450 mm wafer in a 450 multi application container usable within fabrication facilities and usable for shipping wafers between facilities, the multi application container having a door with a central wafer cushion thereon the central wafer cushion usable within fabrication facilities and usable for shipping wafers between facilities, the method comprising installing on the inside front surface of the door a pair of supplemental wafer cushions that are each separate from the central wafer cushion for use for shipping the wafers between facilities, one on each lateral side of the central cushions, the two supplemental cushions supporting wafers in the container on the edges intermediate wafer support shelves and the central wafer cushion.

~~29~~14. The method of claim ~~28~~13 wherein the installing comprises inserting tabs of the supplemental wafer cushions into slots in the door.

~~30~~15. The method of either of claim ~~28~~13 and ~~29~~14 further comprising removing the supplemental cushions, but not the central wafer cushion, after the 450 mm wafers have been shipped.

~~31~~16. A method of shipping 450 mm wafers between facilities in a 450 container for use within the fabrication facility, the container having a door with a central wafer cushion thereon for when the container is used in the fabrication facility and also for when the container is used for shipping wafer between facilities, the method comprising installing on the inside front surface of the door a pair of supplemental wafer cushions that are each separate from the central wafer cushion, one on each lateral side of the central cushions, the two supplemental cushions

supporting wafers in the container on the edges angularly spaced from a centerline perpendicular to the door in a region 30 to 45 degrees from said centerline.

~~32. A shipping wafer cushion used for shipping wafers and for placement on the inside surface of a door adjacent to existing cushions that are used in a fabrication facility and for shipping wafers, the shipping wafer cushion comprising an arcuate portion with a plurality of grooves for engaging the wafers, a spring portion extending from the arcuate portion with a plurality of taps thereon opposite from the spring portion, the tabs for connecting to slots in the door and for putting the spring portion and arcuate portion under compressive tension to secure the spring in place.~~

~~33. A method of shipping 450 mm wafer in a 450 multi application container usable within fabrication facilities and usable for shipping wafers between facilities, the method comprising: providing support to the forward left and forward right edges of wafers in a wafer container, the wafer container having a container portion with opposing wafer supports each with a column of wafer shelves, and a door with a central wafer cushion, the forward left and forward right edges of the wafers being forward of the forwardmost ends of the wafer support shelves on the left side and the right side of the wafer container portion, the providing support including inserting a removable left wafer support to the inside surface of the door laterally outward from the central wafer cushion, the wafer support generally having a V-shaped footprint, and inserting a removable right wafer support to the inside of the door laterally outward from the central wafer cushion, the removable right wafer support having a V-shaped foot print.~~

~~34. The method of claim 33 wherein the wafer cushions are retained to the door by spring loading them before attaching them to the door.~~